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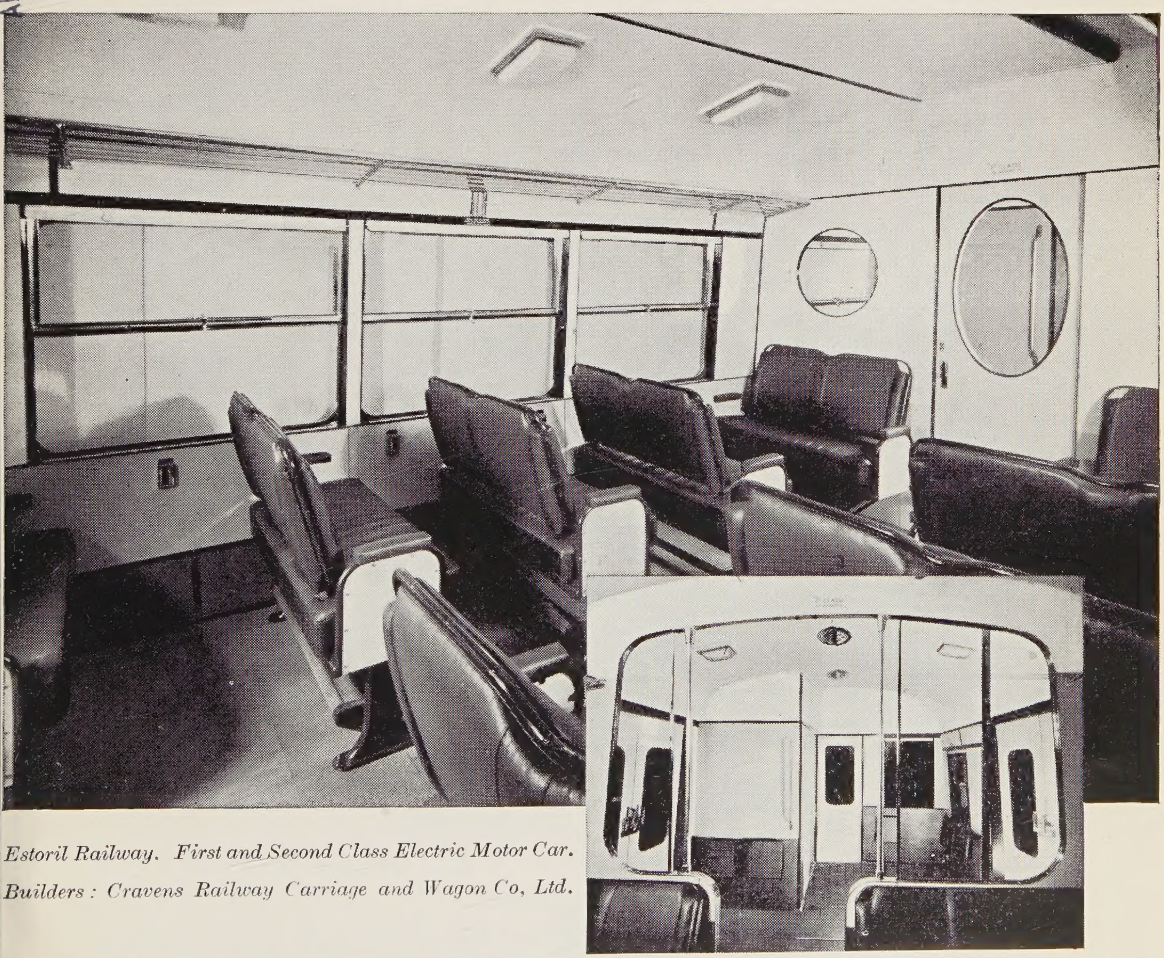

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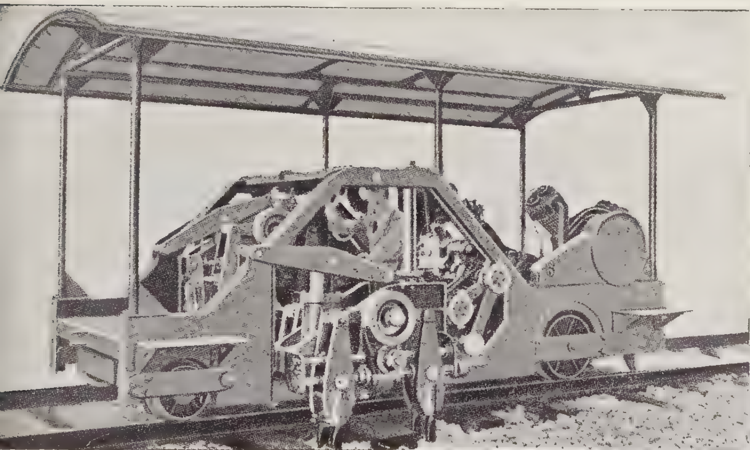

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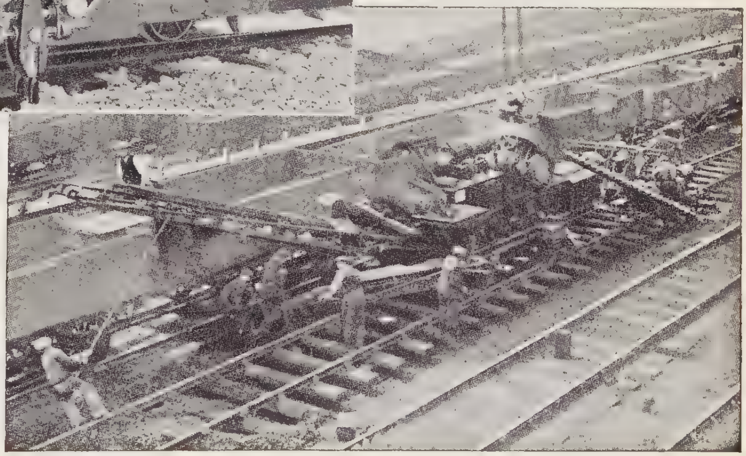

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Alphabetical Index of Advertisers

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(*) This report replaces the translation of the Report by Mr. DERIJCKERE published in our *Bulletin* for May 1950, pp. 849/18 to 875/39.

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Bulletin of the International Railway Congress Association

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It is therefore of greatest interest to know the improvements which have been introduced into the construction of rolling stock with a view to increasing the mileage between repairs; this is one aspect of the question, the other being the study of effective methods of reducing the cost of the repairs themselves.

For this reason the question has been included in the programme for the 15th. Session of the International Railway Congress Association.

This report on the question is based on the replies to a questionnaire circulated to member-Administrations in the countries enumerated above.

The reporters have received replies from the following Administrations :

Spain : R.E.N.F.E. (Spanish National Railways).
Greece : State Railways.
Italy : State Railways.
Portugal and Colonies : Portuguese Railways, Mozambique Railways and Harbours.
Sweden : Oxelösund - Flen - Vastmanlands Railway.
Stockholm-Roslagen Railway.
Turkey : State Railways.

The questions were grouped as under :

A. — General.
B. — Solid wheels.
C. — Tyred wheels.
D. — Axleboxes.
E. — Wearing and friction metals.
F. — Springs.

Each of these groups comprises a Chapter of the report.

CHAPTER A.

General.

1. *State the regulations which govern maintenance and periodic repair of locomotives, carriages, wagons, railcars, etc.*

What are the conditions of wear of details (e.g. the hollowness of tyre before removal) which have led to the fixing of these regulations ?

Periodicity of repairs is in general decided by the necessity for taking up play which develops between parts in contact with relative movement, or restoring the shape of tyres worn below the limits allowed for safe and regular running.

In this respect, the results and possibilities of the various categories of stock show a clear difference.

On locomotives with connecting rods, the coupled axles are not interchangeable, and wear of a single pair of wheels may necessitate turning the whole set; the position is different on locomotives with individual axle drive, where, generally, it is the characteristics of the motors which govern the permissible limits of variation in tyre diameter.

In actual fact, the timely change-over of axles located in different positions in a locomotive can often noticeably defer the turning of tyres. Thus it is found that on locomotives (electric or steam) with coupling rods, the periods between repair and lifting are from 50 000 to 130 000 km (30 000 to 80 000 miles approx.) whilst on locomotives (electric) with individual axle drive the figure often exceeds 225 000 km (140 000 miles approx.).

The frequency of periodical repair is influenced by the type of service (by reason of the diameter of locomotive wheel most frequently used for each service), by the configuration and state of the track and by the general characteristics of the locomotives.

Where railcars with internal combustion engines are concerned, the periodicity of repair would appear to be governed primarily by the necessity for overhaul of the motors.

For trailer vehicles, intervals between repairs are based on time elapsed, rather than on mileage.

The periodicity of repair for trailer vehicles of the Italian State Railways is generally the same as that laid down for lifting.

The lifting period for vehicles working in international services is generally that

specified in the R.I.C. and R.I.V. regulations. Coaches not marked R.I.C. and wagons without S or SS marking can go the full 36 months allowed by the U. T.

At the same time, the Italian State Railways impose a lifting period of 24 months on all vehicles which may run at 100 km/h (60 m.p.h.) and an 18 months period on vehicles which may work at 120 km/h (75 m.p.h.). These periods have been specified by experience to avoid excessive wearing of certain parts (particularly running gear). At overhaul (lifting) periods, the repairs are classified as follows :

Heavy — if at least 2 800 man-hours involved.

Intermediate — if at least 1 200 man-hours are involved, up to 2 800.

Light — if the man-hours involved are less than 1 200.

In general, the sequence of repair is as follows :

Heavy - light - light - intermediate - heavy, etc...

2. *Can it be said generally that mileage between repairs has been increased with improved modern rolling stock and locomotives? If possible give examples.*

The unanimous opinion of the Administration which have replied is in the affirmative. It is pointed out, however, that in the case of electric locomotives with individual axle drive the increased mileage is due essentially to the different methods of axle drive.

It is noted that with steel vehicles of tubular construction, major repairs are spaced at longer intervals and, in particular, the Portuguese Railways report excellent results with the coaches supplied by the American Budd Company.

3. *When ordering new rolling stock and locomotives, is consideration given to maintenance costs in the specification, and if when ordering modern stock are endeavours made to reduce these costs? Indicate if the Railway Administration endeavours to obtain similar results by the modification of stock in service.*

In general, orders for new stock have been replacing stock which no longer conforms to modern requirements. In the design of this stock, the necessity for the most economic maintenance possible has been taken into account.

There is also a noticeable tendency to convert to metal, old coaches with a timber frame, either for the greater safety of the passengers or for increasing mileage between repairs.

CHAPTER B.

Solid wheels.

4. *Have you had experience with solid wheels?*

Several Administrations have tried solid wheels.

5. *If so, what are the results which you have obtained or hope to obtain by using solid wheels from the point of view of regularity of the service?*
 What are the advantages and disadvantages already established?

These wheels are of three types :

— cast-iron (Griffin process);

— cast steel;

— forged or rolled steel.

Wheels of the first two types are not allowed by the U. T. (see § 10) except on unbraked wagons. The Administrations which use them have reported on their already well-known disadvantages particularly the cast iron.

Solid wheels of forged or rolled steel are used on both motor vehicles (electric motor coaches) and on trailers. The most important advantage reported by users is a most obvious one i.e. freedom from slackness.

The R.E.N.F.E. states that this advantage is particularly valuable for systems with long and frequent gradients.

The Oxelösund-Flen-Vastmanlands Railway also reports having been able to achieve by the use of solid wheels, a lighter wheel set, and consequently a higher load-capacity, of the vehicle.

6. *The same question from the cost point of view.*

The Mozambique and Oxelösund-Flen-Vastmanlands Railways report that the initial cost of solid wheels is lower than that of tyred wheels.

The Mozambique Railway also reports a longer life with solid wheels, but these are of cast steel.

Other Administrations which use solid wheels of forged or rolled steel are not in a position to give information on the economic aspect.

7. *Do you use solid wheels on vehicles running at high speeds?*

Solid cast iron wheels are not allowed on vehicles working at high speeds, since the U.T. does not allow vehicles so fitted to be equipped with brakes.

The Mozambique Railway experiences no difficulty with solid cast steel wheels on braked vehicles running at a maximum speed of 100 km/h. (60 m.p.h.).

On the other hand, solid forged or rolled steel wheels are used without any inconvenience on locomotives and carriages up to speeds of 120 km/h. (75 m.p.h.).

8. *Do you use them on braked vehicles (braking on running surface, on brake drum, or on the wheel centres)?*

What material is used for brake shoes? What advantages and disadvantages have been established?

Cast, forged and rolled steel wheels are used without restriction on braked vehicles; cast iron wheels are only used by a few Administrations.

It should be noted, however, that this refers usually to American wagons where the pressure exerted by the brake blocks is low and the maximum permissible speed is also low.

Except for railcars on the Oxelösund-Flen-Vastmanlands lines, which have brake drums, braking is effected by means of cast iron brake blocks applied to the running surface, and for forged or rolled steel wheels no disadvantage is reported, even with vehicles operating at speeds up to 120 km/h.

9. *What metal is used for solid wheels (chemical analysis and physical characteristics)?*

As already stated in item 5, solid wheels are for three types, viz :

— cast iron (Griffin process);

— cast steel;

— forged or rolled steel.

Cast iron wheels are of American (O.S.A.) construction and comply with the A.A.R. specifications.

The cast steel wheels used by the Mozambique Railways comply the U.S.A. or British specifications, according to which of there two countries they are purchased from.

Forged and rolled steel wheels are composed of materials of different qualities:

— steel of the same quality as that specified for tyres (R.E.N.F.E.);

— rolled or specially treated steel to A. A. R. or (Portuguese Railways) A. S. T. M. specifications;

— class 44 steel with 0.2 % maximum carbon for wagon wheels and class 72 steel for railcar wheels (Oxelösund-Flen-Vastmanlands).

10. *Do you use special methods of manufacture in order to obtain the appropriate characteristics of the metal in the different parts of the wheel?*

The various Administrations do not generally have their own specifications for solid wheels. These are ordered from specialized manufacturers.

The R.E.N.F.E. alone reports that to obtain the appropriate characteristics of the metal in the various parts of the wheel, a method of construction is adopted with a « wheel pressing which gives a forging larger than the part corresponding to the tyre ».

11. *Can the solid wheels which you use be re-profiled, by the depositing of metal, by turning, etc., and what are the thickness limits in each case?*

Solid cast iron wheels cannot be reprofiled. Solid cast steel wheels can be reprofiled by turning.

Forged or rolled steel wheels can be reprofiled by turning and by depositing metal. This method, however, is only used by the Oxelösund-Flen-Vastmanlands on solid wagon wheels of class 44 steel.

The metal is deposited up to a thickness of 6 mm. (15/64 in.). This reprofiling has not yet been applied to railcar wheels as class 72 steel would have to be replaced by class 52 steel.

The limit of thickness reported to us (Portuguese Railways) is 25 mm. (1 in. approx.) for carriages and 40 mm. (1 574 in.) for steam and Diesel-electric locomotives.

12. *In the case of wheels having flats do you repair on site by building up by welding and making good the tyre surface by grinding or turning?*

No Administration which has replied to the questionnaire undertakes repair of flats on the site. The Greek State Railways have carried out trials without any great success, which is not surprising, as building up by welding is very difficult on the cast-iron wheels which are used on their system.

The Mozambique Railways, however, report that when the wear of tyres is very heavy and reprofiling would require a deep cut, metal is deposited by electric welding, followed by truing of the profile by grinding or turning as necessary.

13. *After several re-turnings are you able to re-tyre wheels which originally were solid wheels?*

The R.E.N.F.E. and Mozambique Railways have made arrangements for fitting tyres to solid wheels after several returnings.

The Oxelösund-Flen-Vastmanlands provides for re-tyring solid wheels of railcars.

The Portuguese Railways also make such provision, but in certain cases only.

It will be seen that all the cases referred to above deal with Administrations using cast or forged steel solid wheels.

In addition, the Greek and Turkish Railways would undertake the method, but for the difficulty arising from the fact that their wheels are of cast iron.

14. *List the defects such as shelling, scaling, radial cracks or others? Are these defects more or less frequent with solid than with tyred wheels?*

These defects are experienced only with cast iron wheels.

In the case of cast, forged or rolled steel, defects are the same as those experienced with tyred wheels.

CHAPTER C.

Tyred wheels.

15. *What quality of metal of tyres (chemical analysis and physical characteristics, method of manufacture and especially type of heat treatment)?*

The Administrations in countries which do not manufacture tyres adopt the specifications used in the countries which supply them.

High-tensile carbon steel is generally used. The carbon content is reported only

by the Italian State Railways (0.4-0.5), which also give the maximum sulphur ($S < 0.04$) and phosporus ($P < 0.04$) and $S + P < 0.07$. The same S, P and S + P values are reported by R. E. N. F. E.

Ultimate tensile is about 85 kg/mm² (120 898.2 lbs. sq. in.) for locomotive tyres and 75 kg/mm² (106 674.9 lbs. sq. in.) for carriage and wagon tyres.

The only exception is the Oxelösund-Flen-Vastmanlands Railway, which formerly used high-tensile steels (R = 88 kg/mm²—125 165.2 lbs. sq. in.) for locomotives and R = 72 kg/mm² (102 407.9 lbs. sq. in.) for carriages and wagons, but now uses class 52 steel with which tyres can be reprofiled by using deposited metal welded.

As regards heat-treatment, all tyres used by the Italian State Railways are hardened, whilst the R. E. N. F. E. uses normalisation.

16. *What are the measures that you have adopted to reduce to a minimum the risk of loose tyres? (State of surface after machining, diameters of the wheel centres and tyres in contact before mounting, system of heating tyres, etc.). Do you weld at the rim to prevent loose tyres?*

With regard to the contact faces of wheels and tyres, there are divergent opinions.

The Italian State Railways use machined surfaces and this method, which is more expensive, provides a more complete contact between wheel and tyre, resulting in a lower specific pressure and providing a better assembly.

On the other hand, the remaining Administrations, i. e. Stockholm-Roslagen, Greek State, Mozambique, use rough, unpolished surfaces.

The difference in tyre and wheel diameters before heating is between 1.3 and 1.5 ‰ of the diameter. The Stockholm-Roslag uses 1 ‰ difference in diameters.

Tyres are heated by wood, carbon, oil or electric induction.

None of the Administrations which have replied adopts welding at the rim to prevent loose tyres.

17. *What are your specifications regarding the minimum thickness of tyres according to the load or maximum speed permitted for vehicles (minima both after repair and in service)?*

Minimum tyre thickness is generally fixed according to whether the vehicle is motor or trailer.

For locomotives, the minimum tyre thickness is between 35-45 mm. (1.378-1.772 in.) to type. For carriages the minimum is about 35 mm. and four wagons about 30 mm. (1.181 in.). Unbraked wagons have a minimum of 25 mm. (0.984 in.) as provided for by the U. T.

The above values are for vehicles in service. For vehicles leaving the works after repairs they are increased by 2 (Italy) to 5 (R. E. N. F. E.) mm. (0.079 in. to 0.197 in.).

18. *When wheels have flats do you repair by building up by welding and making good the tyre surface by grinding or turning?*

Amongst the Administrations replying to the questionnaire : this method is only in current use on the Turkish Railways; the Greek Railways are using it experimentally and the Italian Railways only use it in specially authorised cases.

19. *In addition to choice of metal and its treatment do you employ other methods to reduce tyre wear (e.g. lubricating flanges or rails)?*

Both the lubrication of rails and of flanges are used.

The Italian State Railways, R. E. N. F. E. and the Greek Railways use flange lubrication, Italy on a large scale and the other two, partly or erperimentally.

The Turkish, Mozambique, Oxelösund-Flen-Vastmanlands and Stockholm-Roslagen use automatic rail lubrication on curves of small radius.

For tyre lubrication of electric locomotives, the Italian State Railways use pads of hair and wool, compressed and held against the flange by a spring holder fixed to the bogie frame.

The pads are capillary fed (second grade mineral oil).

More complicated methods have been tried without any great success.

20. *Have you found with locomotives that the lateral displacement of the axles influences tyre wear?*

Replies on this point are contradictory. No reasons for opinions are given.

It must be remarked that if a locomotive has one or more axles allowing lateral movement, this is governed by the geometrical requirements for conforming to curves. In general, no direct comparison is possible under the same geometrical conditions between axles with and without lateral displacement.

21. *Have you proved that lessening of hunting (particularly lessening the rotation of the bogie round its pivot) reduces tyre wear?*

In general, no direct comparisons have been made.

The Italian State Railways, the Mozambique and the Stockholm-Roslagen Railways consider that lessening the rotation of the bogie around its pivot reduces tyre wear.

The Italian Railways, however, state that this measure was adopted more for improving running stability than for the purpose of reducing tyre wear.

22. *Have you tried or do you use independent wheels? What has been your experience with these wheels regarding tyre wear?*

Amongst the Administrations which have sent replies, only the Turkish State Railways are at present using independent wheels, but no information is given regarding tyre wear.

The Stockholm-Roslagen has carried out trials with one carriage and states that tyre wear was comparatively small. The trial was abandoned for reasons of bearing maintenance.

The Italian State Railways have also undertaken trials with a coach, with the aim of improving running. The trial was abandoned because of tyre wear. Rapid development of tyre sharpness on two wheels located diagonally in the bogie was experienced.

CHAPTER D.

Axleboxes.

a) Roller bearing boxes.

23. *Do you use roller bearings? If so, kindly say what results have been obtained regarding:*
    - *number of hot boxes;*
    - *maintenance costs;*
    - *state period between lubrication and inspection.*

Of the Administrations replying, only the Greek State Railways do not use roller bearing boxes.

Amongst the other Administrations, the Turkish State Railways use a limited number on locomotives and wagons. It is considered that their fitting demands exceptional care and the smallest defect causes serious damage and so gives rise to excessive maintenance costs. The regreasing period is annually.

On the other hand, the remaining Administrations which use roller bearings have had satisfactory results.

As regards maintenance costs, the Oxelösund-Flen-Vastmanlands alone gives details, the figure being seven crowns per pair of wheels per annum.

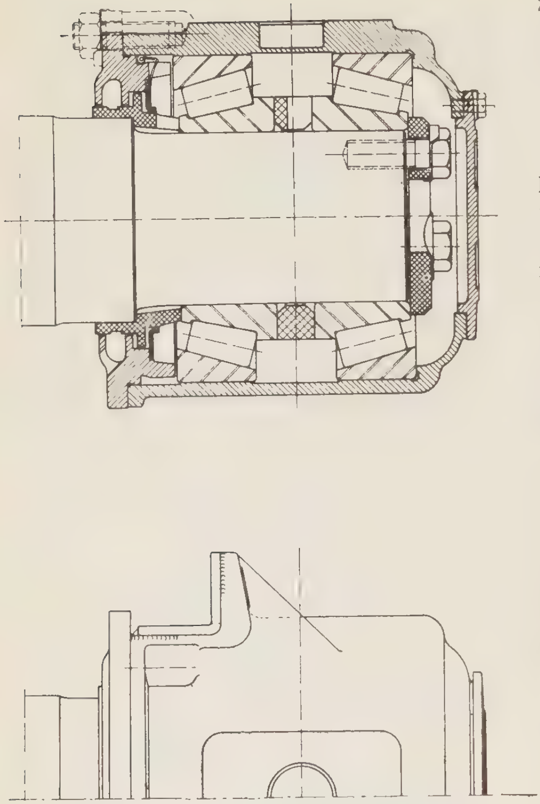

Fig. 1. — *Italian State Railways.* — Standard box, with tapered rollers, for wagons.

The other Administrations agree in stating that costs of maintenance are very much reduced.

With regard to periodicity of lubrication and inspection, there are two methods :

— according to mileage;

— according to time periods.

On the first basis, a mileage of 150 000 km (93 200 miles) is reached, and on the second basis periods vary between one and three years.

The minimum of 3 000 km (1 865 miles) reported by the Mozambique Railways is probably due to local conditions.

24. *Have you found any difficulties due to the use of axleboxes of this type? Please indicate (fractures and wear of details, damage through rough shunting, etc.).*

Only the Turkish State and the Stockholm-Roslagen Railways report difficulties; these are :

fairly frequent breakages of rollers are reported by the Turkish State, and fractures

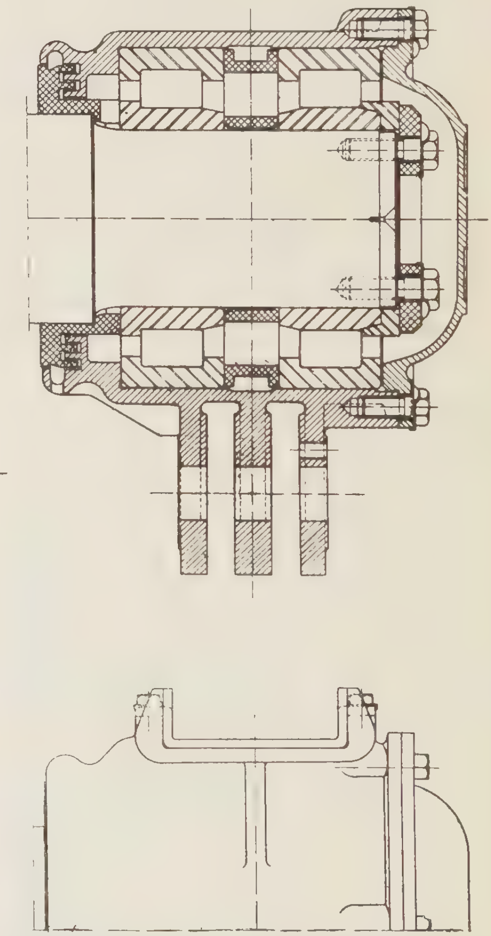

Fig. 2. — *Italian State Railways.* — Cylindrical roller box, for carriages.

of a ring, usually the inner ring, is reported by the Stockholm-Roslagen Railway.

The other Administrations have not experienced any difficulty with the boxes. The Italian State Railways, however, have found that axleguards become distorted more often with roller bearing boxes.

The Portuguese Railways report that several axleboxes have remained in good condition at mileages exceeding 2 000 000 km (1 250 000 miles).

25. *What type of roller bearing box do you use (cylindrical, tapered or roller bearings)?*

There are three types of box : tapered roller, cylîndrical roller and ball bearings. Often Administrations use two types.

The Italian State Railways use tapered roller bearing boxes for wagons (fig. 1) and cylindrical roller boxes for carriages (fig. 2), locomotives and electric motor coaches. In one type of motor coach articulated roller bearing boxes are used.

26. *What type of protection do you use against the penetration of dust and water into the interior of the box?*

Excepting the Turkish State Railways, which use steel plates or special aluminium washers, according to the type of box, and the Mozambique Railways which use a simple felt washer, the Administrations all use a labyrinth system with or without a felt washer.

The Italian State Railways, which formerly used a combined felt-labyrinth system, now use a single labyrinth on modern boxes (fig. 3).

27. *What are the loads per axle and the speeds permitted for the boxes you use? Give principal dimensions, catalogue number, drawing, etc.?*

Axle loads and maximum permissible speeds are very varied according to circumstances.

The Italian State Railways and the R. E. N. F. E. report respectively a speed of 140 km/h (87 m. p. h.) and unlimited speed for carriages with an axle load of 16 tons (metric) and a very high permitted velocity. The Oxelösund-Flen-Vastmanlands has an axle load of 15 tons, speed 120 km/h. (75 m.p.h.) and the Portuguese Railways 10 tons and 120 km/h. (75 m.p.h.).

Higher axle loads are found on locomotives (19-20 tons) of the Italian State Railways, Portugese Railways, Mozambique Railways and on wagons. The Italian State Railways, which have a general limit for wagons on their system of 16 tons, raise this figure to 20 tons for wagons fitted with roller bearing boxes in order to allow for future needs.

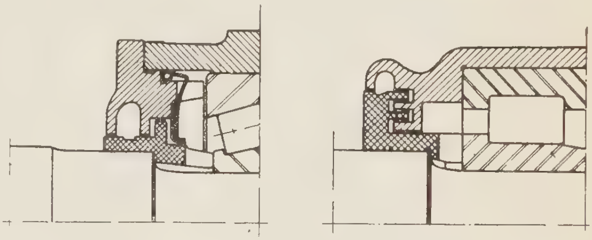

Fig. 3. — *Italian State Railways.* — Labyrinth packing for roller bearing boxes.

Journal diameter is in proportion to the load, speed and type of box. Vehicles of the latest types have journal diameters of between 120-130 mm. (4.724-5.118 in.).

The U.I.C. has laid down standard exterior dimensions for wagon axleboxes, and the Italian State already have a certain number of these standard boxes.

28. *What is the system of mounting the rollers on the journal?*

What are the advantages and disadvantages of the system used?

There are two methods of mounting the rollers :

— direct bearing on the journal (Timken and R.I.V. boxes);

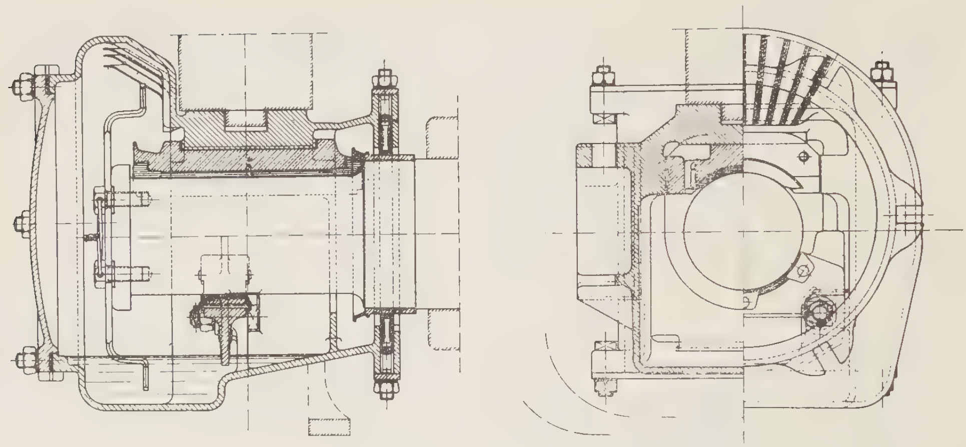

Fig. 4. — *Italian State Railways.* — « Athermos » box.

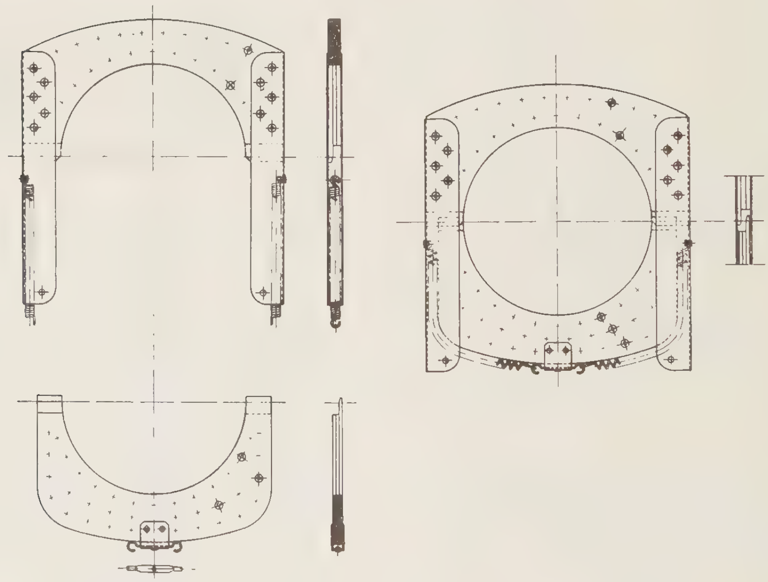

Fig. 5. — *Italian State Railways.* — Two-piece dust shield for « Athermos » box.

— indirect bearing on the journal through a removable conical sleeve (S.K.F. boxes).

With the first system, errors in assembly are almost impossible, but dismantling, which is sometimes necessary for journal inspection, can damage the journal itself.

With the second method the rollers can

be removed without difficulty and without damage to the journal. There is, however, the disadvantage that the inner ring can fracture or may turn on the journal if it is not meticulously fitted.

29. *Do you use special arrangements to prevent electric current passing through the roller bearings (current for traction or heating)?*

Of the Administrations which use roller bearings on electric locomotives, only the Stockholm-Roslagen uses a contact device at one end of each bogie axle.

These are not used on electric motor coaches however.

The Italian State Railways use carbon brushes bearing on collector rings keyed to the axle or hollow shaft.

They consider, however, on the basis of experience, that in cases where it is possible to set up a direct contact between the body of the vehicle and the wheels, across plain bearings (supporting bearings of nose-suspended motors or bearings on hollow shafts) defects in the rollers of axleboxes are not likely, even without the brushes mentioned.

b) **Axleboxes with bearings or brasses other than ordinary axleboxes with oil pads or packing.**

30. *Describe what types of axleboxes having bearings or brasses other than ordinary axleboxes you use.*

Except for the Oxelösund-Flen-Vastmanlands, Stockholm-Roslagen and Mozambique, which use only ordinary axleboxes, the Administrations use Athermos or Isothermos axleboxes on a more or less extensive scale.

The two types of boxes have the same characteristics (see fig. 4) as the Athermos boxes used by the Italian State Railways.

The Portuguese Railways also use boxes with lubrication by special grease blocks of American pattern.

31. *What is used for the lubrication of these axleboxes (grease or oil)?*

Isothermos and Athermos boxes are generally lubricated with mineral oil.

R. E. N. F. E. uses a compounded mineral and vegetable oil.

32. *What type of protection is used against the penetration of dust and water to the interior of these axleboxes?*

A felt shield is generally used, either plain or with a stiffener. The Greek Railways use a leather stiffener or backing.

The Italian State Railways use a two-piece shield (see fig. 5).

R. E. N. F. E. uses leather and felt, the Turkish Railways aluminium washers and the Oxelösund-Flen-Vastmanlands masonite sheet with leather sleeves.

c) **Improvements to ordinary axleboxes with bearings and brasses.**

33. *What improvements have you carried out to brasses and oil pads?*

In general oil pads have been improved by higher quality wool and by using one-piece wicks. The Mozambique Railways use « packing ».

With regard to bearings, the Oxelösund-Flen-Vastmanlands reports having increased the thickness of the bearings and adopted certain tolerances which increase the life of the bearing.

The Italian State Railways report the adoption for carriages of an anti-friction metal with a higher tin content, and have designed for wagons a special bearing with steel carrier and anti-friction lining of copper alloy (Cu 69, Pb 30, Zn 1) cast separately and pressed in.

34. *What type of anti-friction alloy is used? Is there a preference for the use of anti-friction metal rich in tin, according to the type of vehicle (load and speed)?*

The type of anti-friction metal used varies greatly according to the type of vehicle on which it is used.

For locomotives and carriages of express trains high tin (80-85 %) metal is used, the other components being Cu 5-6 %, Sb 10-13 %.

Other vehicles have bearings with a lower tin content. In this case the average composition in very frequent use is as follows :

Sn 10-15 %, Lead 70-75 %, Antimony 10-15 %, Copper 1.5-4 %.

Anti-friction metal is usually applied by grinding. Some Administrations use either centrifugal application or grinding, according to circumstances (R. E. N. F. E. and Italian State).

The Stockholm-Roslagen uses only centrifugal application.

The Italian State Railways also report that they apply, by pressing, a Cu-Pb anti-friction lining on a steel carrier (see fig. 6). The anti-friction lining is produced by grinding, but trials have been undertaken with liners applied by fritting.

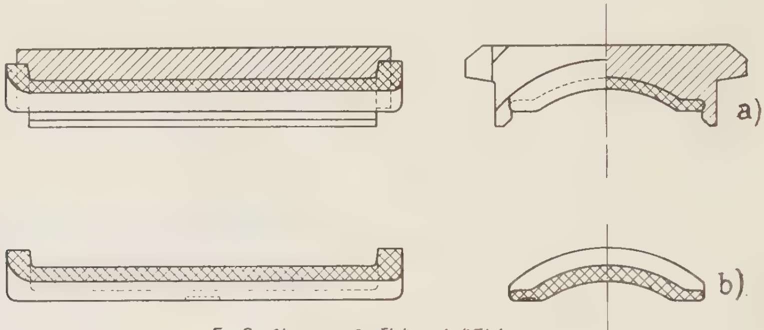

Fig. 6 _ *Chemins de fer Italiens de l'Etat.*

Coussinet en acier avec semelle antifriction Cu-Pb *moulée séparement.* a) *coussinet complet;* b) *semelle.*

Fig. 6. — *Italian State Railways.* — Steel bearing with antifriction liner of Cu-Pb cast separately; *a*) complete bearing; *b*) liner.

The Portuguese Railways also use a bearing metal with tin content between these two (Sn 40%, Sb 14.5%, Cu 3%, Pb 42.5%).

The present tendency is to use high tin content for express vehicles.

It may however be remarked that the Portuguese and Italian Railways also use a Cu-Pb metal. The composition of this is a follows : Cu 69 %, Pb 30 %, Zn 1 % and is being used on a large scale on wagons.

35. *Describe the methods of applying the anti-friction metal (grinding, centrifugal, sintering, fritting, etc.) and the minimum thickness of the layer?*

The minimum thickness of the anti-friction layer is generally 4-5 mm. (0.157 to 0.197 in.). With a new bearing the layer is about 7-8 mm. (0.276 to 0.315 in.).

d) **Present practice in the choice of the type of box.**

36. *Set out the different categories of locomotives and rolling stock, and the various types of service which govern the choice of the type of boxes to be adopted, showing the reasons.*

All the Administrations consider that express vehicles, or those used for expen-

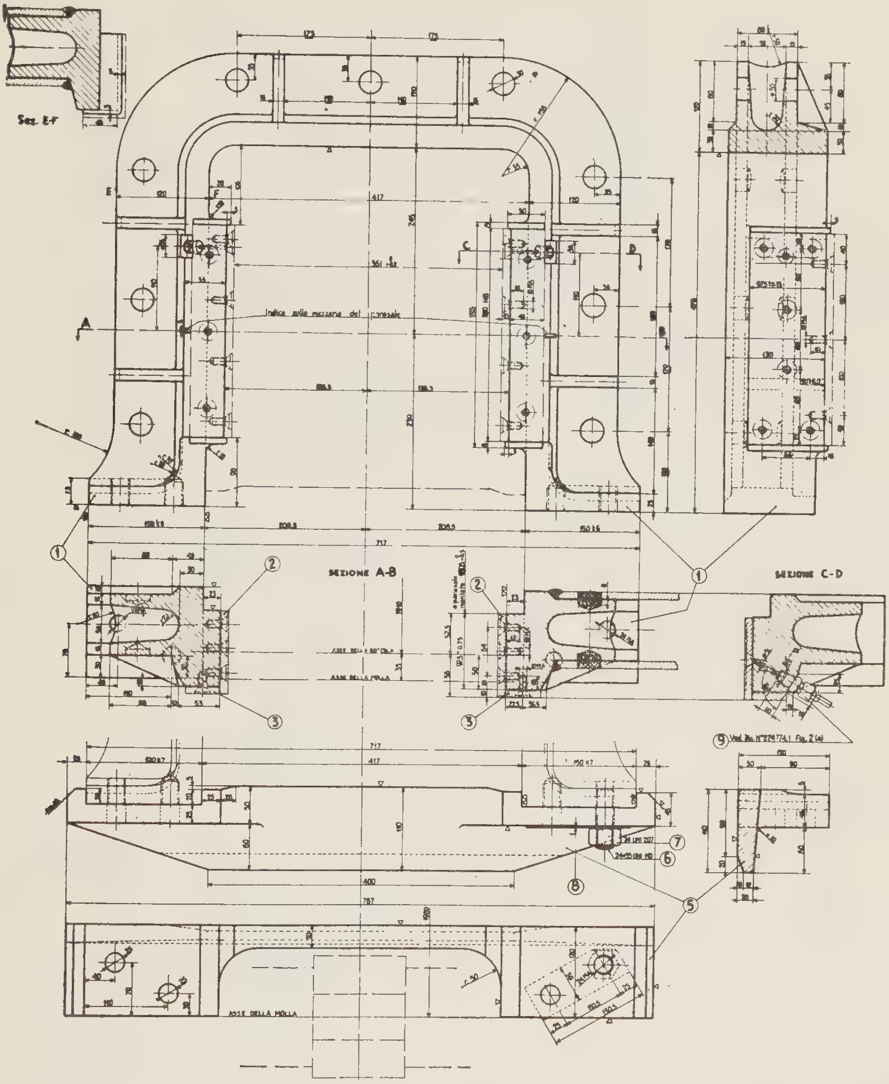

Fig. 7. — *Italian State Railways.* — Axlebox guide plate for electric locomotives, with plastic wearing plates.

sive traffic (e.g. refrigerated wagons) can with advantage use roller bearing axleboxes in spite of their higher cost. This higher cost is justified by the greater ease of running, the lower maintenance cost and the clear reduction— or complete elimination — of heating.

The R. E. N. F. E. is providing Isother-

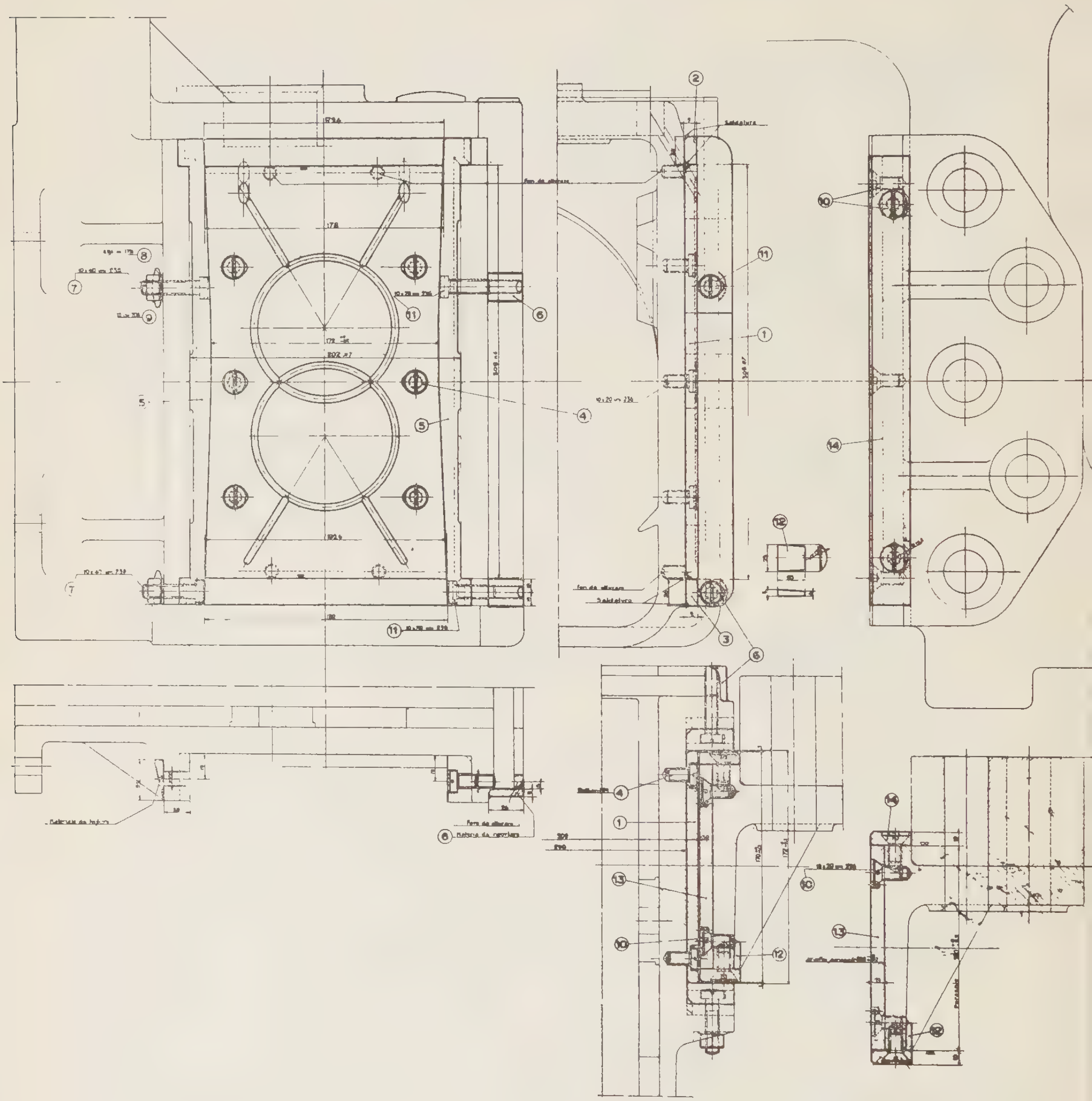

Fig. 8. — *Italian State Railways.* — Electric locomotive axlebox with plastic wearing plates.

mos or Athermos boxes for the same reasons.

The Turkish State Railways consider, however, that the use on their system of roller bearing boxes, which are very expensive, is not justified, as speeds are not very high. They are considering the adoption on a large scale of Isothermos boxes, which are not so expensive and permit constant automatic lubrication with economy of lubricant.

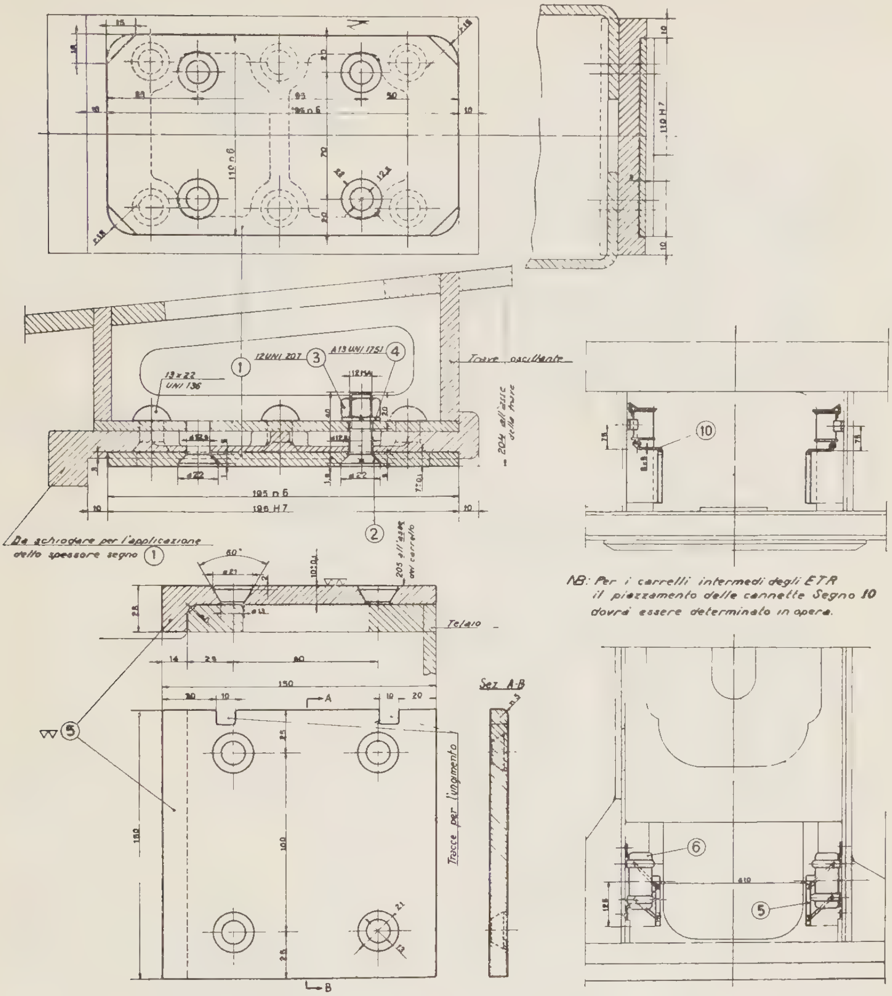

Fig. 9. — *Italian State Railways.* — Swing bolster of a unit in a rail motor set, with plastic wearing plates.

CHAPTER E.

Wearing and friction metals.

37. *What are the details, in your opinion, the wear of which limits the mileage between repairs?*

It is usually tyre wear which governs mileage between repairs. On locomotives with coupled wheels, mileage is also governed by wear of bearings, cranks and coupling rods and the play which develops between the axlebox slides and the horns.

The Italian State Railways report that it is necessary to carry out supplementary repairs to rolling stock (carriage and wagons) R.I.V. and R.I.C. regulations.

With regard to railcars it is the requirements of the motors and transmission which limit mileage between repairs.

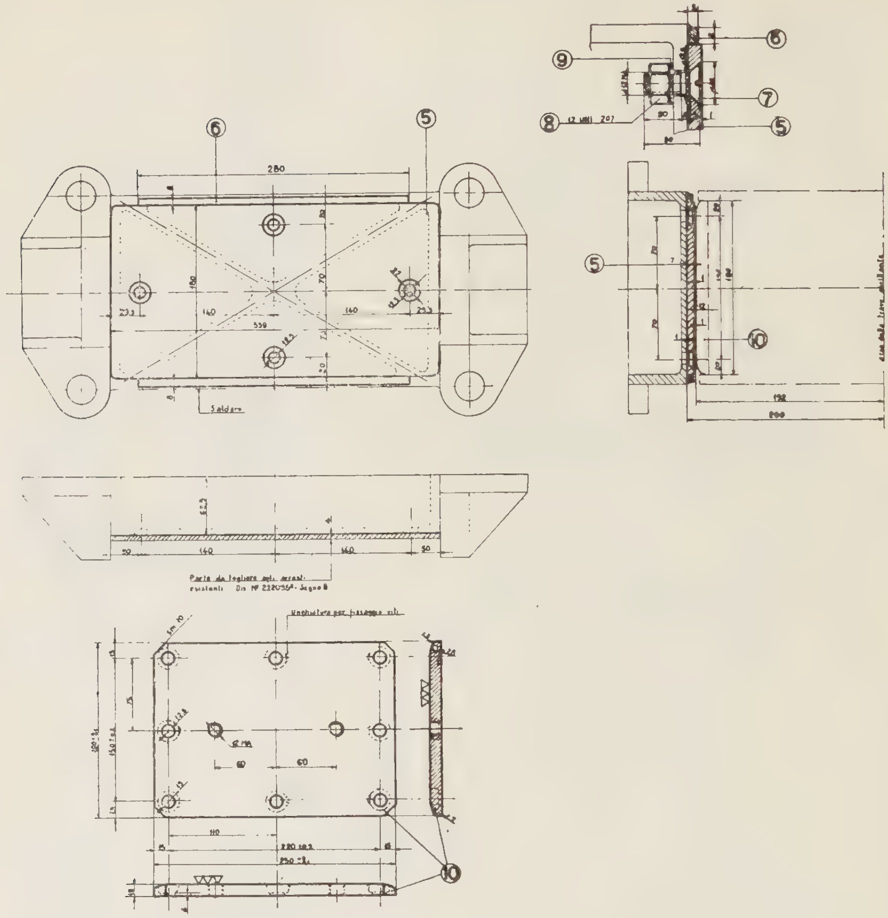

Fig. 10. — *Italian State Railways.* — Slides of swing bolster on a unit of a rail motor set, with plastic wearing plates.

38. *What materials are used to reduce the wear of details subjected to friction (axlebox guides, various joints, etc.)?*

To reduce wear of parts subject to friction, hard materials such as hardened steel, phosphor bronze or cast iron are used. The Italian State Railways also report the use of bakelite type plastic in combination with woven textile (cotton).

39. *What methods have you adopted to make good worn details (e.g. fitting washers or bushes at joints, using easily replaceable wearing portions, etc.)?*

Usually, washers are used at joints and wearing plates for friction parts (axlebox guides, liners for axleguards, for example).

By these means a greater resistance to wear and easier replacement of worn parts is achieved.

In certain cases, in order to facilitate replacement, openings are cut into the wearing washers.

Figs. 7 to 12 shew several examples of

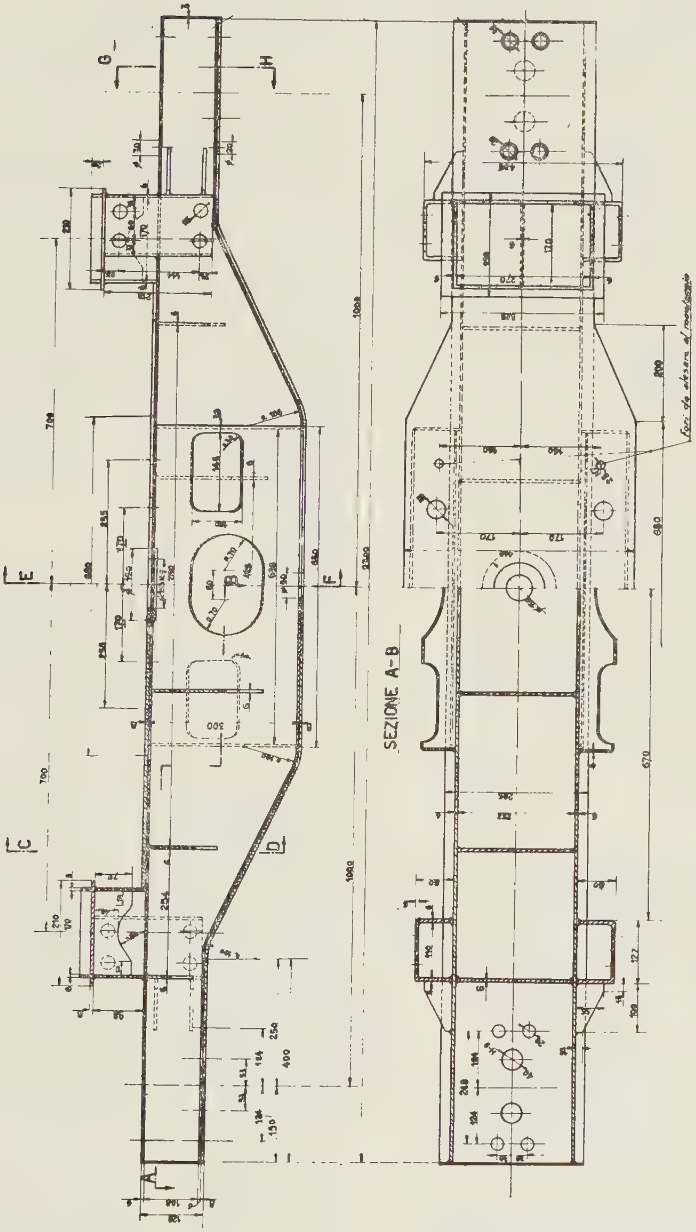

Fig. 11. — *Italian State Railways.* — Plastic bearing plates of swing bolster on a unit of a rail motor set.

applications made by the Italian State Railways :

— to axleguards and axleboxes of electric locomotives (see figs. 7 and 8);

— to slides (figs. 9 and 10) and bearing surfaces of swing bolsters on units of electric motor set (see fig. 11).

In addition, to avoid rapid wear producing play which is inadmissible for proper running, the Italian State Railways use rubber seatings below the wearing plates to take up the play between the axleguards and the boxes as it develops (see fig. 12).

40. *Have you adopted any special arrangements to avoid reciprocal friction between the different details (e.g. guiding by articulated links on silent bloc, etc.)?*

Link guiding of axles or swing bolsters is used on railcars, rail motor coaches, electric locomotives and carriages.

Fig. 13 shews the bogie of an Italian State Railways coach with link-guided axles.

A similar method of guiding the axles is used by the same Administration on two-axled carriages. As these have wheelbases of 11.20 m. (45 ft 11 3/16 in.) to allow the axles to move radially, the links are articulated at the ends on an equaliser (see fig. 14). These links include laminated springs and provide for lateral displacement.

In other cases friction surfaces have been replaced by rolling bearing surfaces, as shewn in fig. 15, which shews the suspension bar bearing of an electric motor coach of the Italian State Railways. The results obtained are excellent, provided the contact surfaces are sufficiently hard.

41. *Do you use with spring suspension details any production devices on the parts subjected to friction (supports for the adjusting spring links, buckles, etc.)?*

No reports have been received, other than the use of extra-hard steel washers on joints of suspension links.

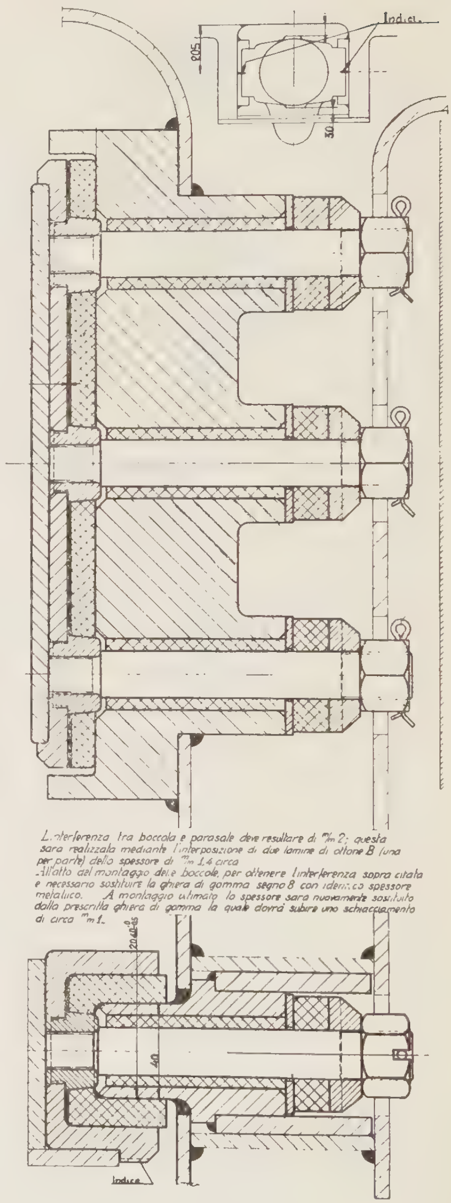

Fig. 12. — *Italian State Railways.* — Rubber lining of rail motor axlebox guide for automatic compensation of wear.

CHAPTER F.

Springs.

42. *What methods have you adopted to lessen the number of spring failures (weakening, fractures, etc.)?*
    a) *for laminated springs;*
    b) *for spiral springs;*
    c) *for volute springs;*
    d) *for other types of springs (torsion bar, etc.).*

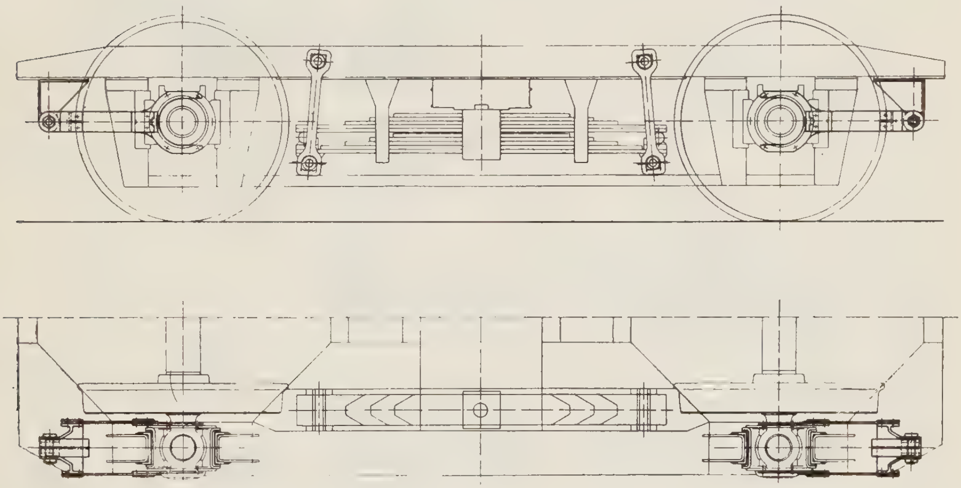

Fig. 13. — *Italian State Railways.* — Guide links for bogie axles, and swing bolster suspension with two-part spring.

In general, no special method is used for reducing the number of spring failures, other than careful supervision of manufacture, particularly with regard to heat treatment.

The Oxelösund-Flen-Vastmanlands Railways uses suspension links which can be adjusted vertically to reduce failures of laminated springs.

R.E.N.F.E. anticipates reducing the number of spring failures by using Silico-manganese steel, while the Italian State Railways, for electric motor coach springs (laminated and coil), use high-quality steel, having the following characteristics after heat treatment :

R = 160 kg/mm² (101.6 tons per sq. in.);
S = 150 kg/mm² (95.23 tons per sq. in.);
A5 = 5 %; K = 2 kg/cm² (28.44 lbs. per sq. in.).

The same Administration shows a tendency towards using springs with laminations in two or three groups (two or three-part springs) separated and grouped in the same buckle. These springs give like flexibility with lesser deflection, and reduce the resultant friction (fig. 13 shews a two-part spring).

43. *Are these failures brought about by the quality of steel, the design of spring, or manufacturing processes (state especially if you use oil or water hardened steels and the results obtained in each case; state quality of the steel used)?*

    In those cases where the quality of steel is the cause, what arrangements have you adopted to ensure the consistent quality of steel? Attach specifications and state what steps you take to ensure the correct quality of steel being supplied.

Failures reported arise mainly from heat treatment badly carried out and sometimes from defective material.

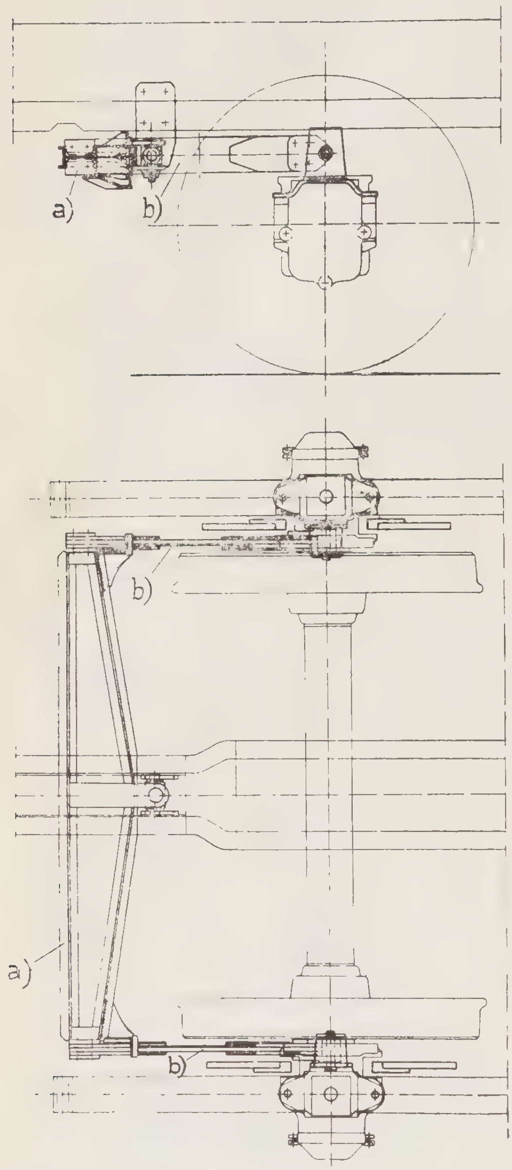

Fig. 14. — *Italian State Railways.* — Guide link for radial axle : *a*) equaliser; *b*) flexible links.

Water or oil hardening is used.

The Italian State Railways report that the steel which they use for ordinary springs has the following characteristics :

normal : R-75 kg/mm^2 (47.62 tons per sq. in.); A_5 12 %;

after heat treatment : R-130 kg/mm^2 (82.54 tons per sq. in.); A_5, 5 %.

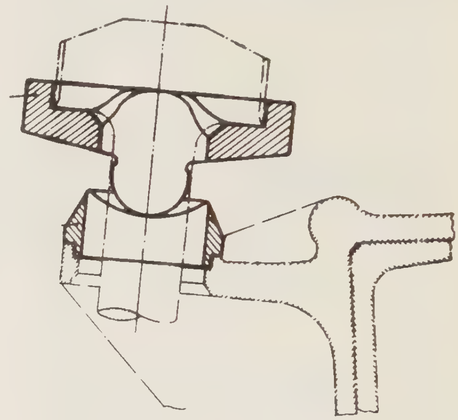

Fig. 15. — *Italian State Railways.* — Bearing for suspension of electric motor coach.

Heat treatment consists of hardening from 850-880° in water at 20° followed by heating to about 450° for 20 or 30 minutes according to the section of spring. No specification is given of the composition of the steel.

Other Administrations refer to the Belgian, R. E. N. F. E., British or American (Mozambique) specifications, according to the country from which the material used is supplied.

44. *Do you use special mounting arrangements in order to prevent movement not provided for (guiding, joints in the case of spiral springs, etc.)?*

The Stockholm-Roslagen Railway reports the use of sleeve guides for coil springs.

The Italian State Railways also report that in the case of volute or coil springs, guides are used where there is a possibility

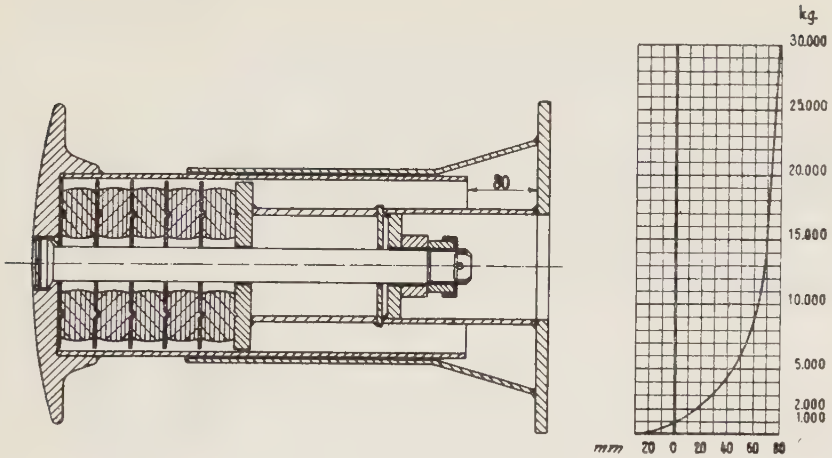

Fig. 16. — *Italian State Railways.* — Standard buffer with rubber springs and relative diagram.

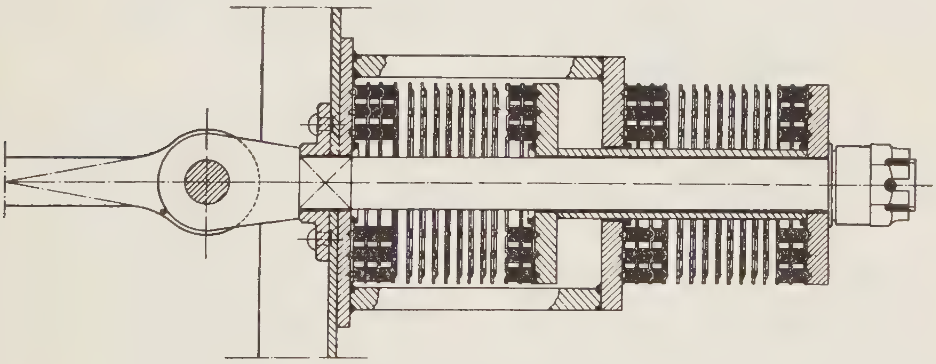

Fig. 17. — *Italian State Railways.* — Drawgear with rubber springs.

of axial displacement of the parts between which the spring is applied.

For coil springs this guiding is necessary for the spring itself if the height is excessive and in practice a sleeve, usually inside the spring, if the height when loaded exceeds the diameter of the coil.

45. *Are laminated springs buckles fitted hot or cold? State methods process and results obtained?*

In the large majority of cases buckles are pressed on cold.

The Italian State Railways report that cold fitting is done by a press which develops 100 tons in two orthogonal directions.

46. *What method do you use to prevent the buckle sliding longitudinally along the leaves, one in relation to the other?*

Two methods, both well-known, are used to prevent longitudinal movement of leaves:

— by a central peg, which keys the plates, the two ends being bent against the buckle;

— by studs and corresponding holes in the centre of each spring, and a key with peg and socket also located against the buckle.

Each of the two systems is used on a large scale and gives complete satisfaction.

The Italian State Railways also report that they have used a lateral key, but this has been discontinued because it gave rise to frequent breakages of leaves at the key socket.

47. *Do you use rubber springs (for suspension, for shock and for drawgear, etc.)? What are the results obtained?*

Only the Greek and Turkish Railways do not use rubber springs.

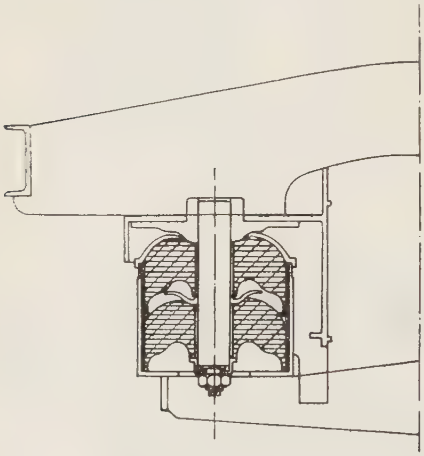

Fig. 18. *Italian State Railways.* — Suspension spring with rubber in shear.

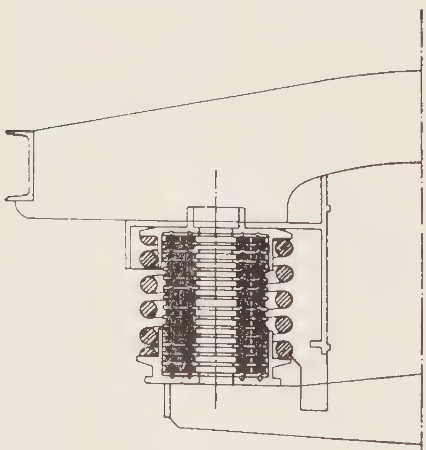

Fig. 19. — *Italian State Railways.* — Suspension spring combined with rubber in compression.

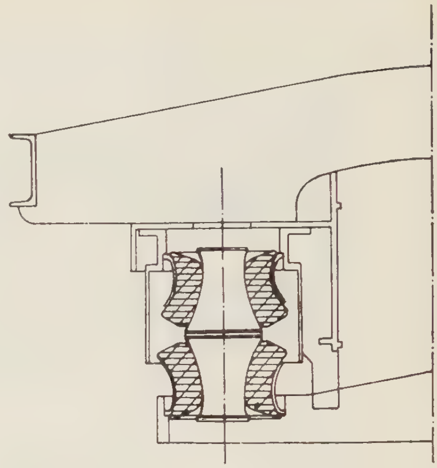

Fig. 20. — *Italian State Railways.* — Rubber suspension spring working in shear and compression.

The other Administrations use them, usually for buffing and drawgear, with satisfactory results except on the Mozambique Railways, where they are now being replaced by steel springs.

The Italian State Railways use them for buffing gear (fig. 16) and drawgear (fig. 17) and for suspension on bogies of modern vehicles.

In this respect, various methods of suspension have been used :

— springs in which the rubber works in shear (fig. 18);

— springs with rubber under compression jointly with a steel spring (fig. 19);

— springs in which the rubber works partly in shear and partly in compression (fig. 20).

The results obtained with all these systems have been quite satisfactory.

The arrangement shown in fig. 19 has had numerous applications and trials are still in hand to determine the most favourable arrangement, from a running point of view, for distributing the load between the outer steel spring and the inner rubber spring.

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

15th. SESSION (ROME, 1950).

QUESTION XII.

What must the importance and the prevailing conditions of traffic be, in order that from the economic point of view :

a) the construction of a railway line;

b) the keeping operating an existing railway line;

should be useful ?

SUPPLEMENT TO REPORT (*)

(Great Britain and North Ireland, Dominions, Protectorates and Colonies, America (North and South), China, Burma, Costa Rica, Egypt, India, Malayan States, Pakistan, Iraq, Iran),

by Sven BOYE, cand. act.,

Divisional Officer, Norwegian State Railways.

PART I.

Since my report was completed I have received replies to the questionnaire from the following :

The Railway Board (Indian Government Railways), South African Railways and Harbours, Sudan Railways.

I. KEEPING EXISTING LINES IN OPERATION.

QUESTION I.

Taking into account capital repayments, does your operating budget show a deficit for the last two years, as well as for the years prior to 1939?

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

The system of capital repayments is not in vogue on the Indian Railways.

SOUTH AFRICAN RAILWAYS.

The operating results, after payment of interest on capital, of the South African Railways (excluding Harbours, Steamships, Airways and Aerodromes) for the last two completed financial years and the five years prior to 1939 are as follows :

Year ended	Surplus £	Deficit £
31st March 1949	—	6 094 190
31st March 1948	—	1 628 434
31st March 1939	3 484 431	—
31st March 1938	5 582 106	—
31st March 1937	6 464 021	—
31st March 1936	5 623 158	—
31st March 1935	3 888 725	—

(*) See *Bulletin of the International Railway Congress Association,* February 1950, p. 111/1.

As the Administration does not redeem its capital there is no provision for capital repayments included in above figures.

SUDAN RAILWAYS.

The operating budget does not show a deficit for the last two years, nor during the five years prior to 1939.

QUESTION 2.

Who met the operating deficit? What amount is carried by the State? What rating policy does the State impose on you?

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

The operating deficit is met by the Reserve Fund maintained for the purpose. So far as rates are concerned, the State fixed statutory maxima and minima within which rates were to be quoted. With regard to the last part of this question, the State prescribe certain maxima and minima within which rates must be fixed.

SOUTH AFRICAN RAILWAYS.

In the year ending 31st March 1948, the operating deficit was entirely offset by surpluses on the Harbours and Airways services.

In the following financial year, the net deficit, after deducting the surpluses earned by Harbours and Airways, was financed from a reserve fund called the Rates Equalisation Fund, which has been built up from the surpluses earned in previous years.

SUDAN RAILWAYS.

Does not arise; please see reply to question 1 above.

QUESTION 3.

Do you collect statistical data to determine the amount of traffic on each of your lines? What methods do you follow in the case of passenger traffic and goods traffic? How are your lines distributed amongst the various categories of traffic density adopted by you?

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

Statistics of the volume of traffic moving over the various lines of the Indian Government Railways are being collected and maintained.

As regards the last part of this question, the Indian Railways have no system of classification of railway lines according to traffic density.

SOUTH AFRICAN RAILWAYS.

Save in the case of guaranteed lines statistical data are not extracted to determine the quantity of traffic (goods- or passengers) traversing, emanating from, or destined for a particular line. In so far as guaranteed lines are concerned, particulars of traffic passing over such lines are retained for the purpose of determining the payability or otherwise thereof.

In view of what is stated above the last part of this question does not apply.

SUDAN RAILWAYS.

The volume of traffic on the whole of the system is very small compared with many railways, and at this stage data are not abstracted for the different lines. Statistical data are abstracted for the system as whole monthly.

QUESTION 4.

Do you also collect statistical data in order to ascertain fluctuations in the traffic at different times of the year, on different days of the week, etc.? Do your statistics enable you to establish the degree of concentration of the traffic on the different lines, taking periodical fluctuations into account?

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

Normally statistical data are compiled monthly and a study of the position from month to month shows the trend. Day to day figures are maintained at the District Headquarters and Railway Headquarters in respect of certain items such as punctuality of passenger trains and movement of wagons, but it is customary to probe into day to day fluctuations. Sectional, district or divisional figures maintained on railways enable conclusions to be drawn on the degree of concentration of traffic on differ-

ent sections, districts or divisions; and railwaywise figures maintained in the office of the Railway Board at Dehli give the position relating to railways.

SOUTH AFRICAN RAILWAYS.

Statistical statements (train miles, engine miles, gross ton miles, tonnage of goods, etc.) covering monthly periods are prepared as a matter of ordinary routine, but are not sufficiently detailed to indicate fluctuations on different lines or on different days of the week. Any such information would require special investigation which would only be undertaken in connection with a specific inquiry.

SUDAN RAILWAYS.

No, at present statistics are used only as a check of railway working, and provide the data for arriving at decisions regarding rates and working.

QUESTION 5.

Do you set out separately the costs and receipts for each of your lines, in such a way as to establish partial budgets for each line?

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

The Indian Government Railways are divided into separate well defined units for which accounts are separately maintained and budgetary control exercised by the General Manager of each of the systems. Figures are not maintained for each section or district, but they are maintained according to railways and separate budgets are drawn up for each individual railway. In the case of individual railways where lines are worked for third parties, receipts are maintained and pro-rata costs are also debited.

SOUTH AFRICAN RAILWAYS.

No. This procedure is followed only in connection with certain branch lines, the operating results of which are guaranteed by outside interests, and in the case of the lines in South-West Africa.

SUDAN RAILWAYS.

No. Data for lines are not given separately.

QUESTION 6.

Have the above mentioned statistical data enabled you to determine the class of lines the amount of traffic on which has an adverse effect on the financial stability of your railway system as a whole?

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

The answer is in the affirmative.

SOUTH AFRICAN RAILWAYS.

In view of what is stated in reply to question 5, this question does not apply.

SUDAN RAILWAYS.

Does not apply. Please see reply to question 5.

QUESTION 7.

Amongst the lines showing a deficit, what is the approximate percentage of lines which it is necessary to keep in operation :

1. *For technical reasons (exceptional traffic on the main lines, interruptions in the normal routing, etc.)*;
2. *For economic reasons special to the operating company*;
3. *For political, social, etc., reasons.*

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

The Indian Government Railways are, for purposes of financial considerations, taken as one unit and their operation has shown a surplus.

SOUTH AFRICAN RAILWAYS.

Not applicable.

SUDAN RAILWAYS.

Please see reply to question 5.

QUESTION 8.

Are you of the opinion that a more adaptable rating policy or a different form of operation and

organisation of the lines showing a deficit would improve their present financial situation? Do you think it might be advantageous to suppress one or other service?

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

The rating policy is already sufficiently elastic to provide for any adjustments that may be necessary. Separation of one or the other service should not be called for.

SOUTH AFRICAN RAILWAYS.

The Railways and Harbours Control and Management Act (Act 22 of 1916) prescribes that all freight and fares for goods and passenger traffic shall at all times be charged equally to all persons. In view hereof, even were the Administration in a position (which it is not) to determine whether any particular line, or section of line, is showing a deficit, it would be precluded from remedying the matter by the adoption of a rating policy calculated to increase charges over such line, or section of a line, to the detriment of certain users.

In view of the circumstances outlined above, the last part of the question does not apply.

SUDAN RAILWAYS.

Please see reply to question 5.

QUESTION 9.

Do you consider that lines at present operated by different companies or administrations could with advantage be regrouped, reorganised, divided up, etc.?

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

Most of the lines in the country at present are owned by the Government and certain proposals for regrouping are under consideration.

SOUTH AFRICAN RAILWAYS.

Not applicable.

SUDAN RAILWAYS.

Does not apply on this railway.

QUESTION 10.

What is the policy of the State as regards protecting the railways against road competition? (Please give the measures adopted by the State in order to prevent the railways losing their traffic and the progressive depreciation of the capital invested in them).

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

The policy advocated and which is being gradually implemented is in respect of :

a) *Passenger services.* — Financial association of the railways in conjunction with the Provincial Governments in nationalised (provincialised) road passenger transport undertakings with the object of providing, in the public interests, the best possible service by both forms of transport with the avoidance of wasteful overlapping.

b) *Freight services.* — Road competition is not unduly intense at the present time and to prevent a return to the conditions which existed before the war, Central and Provincial Governments are determining jointly the appropriate sphere of the lorry and the goods train. Broadly speaking, road transport will not be permitted to compete for long distance goods traffic, but railways will not go out of their way to compete for short distance traffic, although they will be compelled to meet statutory obligations.

SOUTH AFRICAN RAILWAYS.

Legislation for the regulation and control of road motor transport in the Union of South Africa was introduced in 1930, since which time such transport has been governed by the provision of the Motor Carrier Transportation Act (No. 39 of 1930, as amended). Briefly, this control, which aims at the protection of both rail and road motor transport, provides that motor carrier certificates or exemptions, according to whether the transport is for reward or in the course of a business, must be obtained before such transport is undertaken.

Control is exercised by Local Road Transportation Boards appointed for specific

areas, whose function is to receive and consider applications for (*a*) motor carrier certificates and for exemptions transport for reward and (*b*) exemptions covering the use of transport in the course of a business, trade or industry and in their discretion to grant such applications in full or in part or to refuse them in their entirety. A Local Board is required, before granting or refusing any application for a motor carrier certificate, to take into consideration *inter alia*:

a) the extent to which the transportation to be provided is necessary or desirable in the general public interest;

b) the need for providing the public within the area or along the route in or over which the applicant proposes to operate, with an adequate, suitable and efficient transportation service;

c) the existing transportation facilities available to the public in that area or over that route;

d) the co-ordination of all forms of transportation, including transportation by rail, on an economically sound basis and with due regard to the public interest;

e) the question of whether the public interest requires the provision of transportation services at less than the cost thereof,

f) the ability of the applicant to provide in a manner satisfactory to the public the transportation for which a certificate is sought;

g) any representations by local authority or the Department of Native Affairs;

h) any other factors which in its opinion may affect the question whether it is desirable to grant such application.

Exemptions are granted for the use of motor transport in connection with a business, trade or industry in respect of the delivery of goods by their seller to their purchaser or by their purchaser on their removal from the place where he purchased them or by their owner to a place where he intends to sell, use or store them. A statutory radius of 30 miles is prescribed for such ancillary transport except in the Witwatersrand and Cape Peninsula areas, where larger areas, comprising several magisterial districts, are permitted. It is obligatory upon the Local Road Transportation Boards to grant exemption for the use of ancillary transport within the radius or areas stated, but they may, at their discretion grant larger areas or permit conveyance between particular points beyond the statutory area in cases where, in their opinion, it would be unreasonable in the circumstances to expect the business, trade or industry concerned to make use of any other form of transport.

SUDAN RAILWAYS.

At present, owing to lack of permanent through roads in the Sudan, serious road competition does not arise.

QUESTION 11.

What are the financial effects of road competition on the railway?

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

At the present time railway finances are not seriously affected by road competition and it is hoped that vigorous implimentation of the co-ordinated policy now accepted will adequately safeguard railway finances in this respect in future.

SOUTH AFRICAN RAILWAYS.

Experience has shown that private road carriers operating in competition with the railways usually cater on a selective basis, for the traffic which, when conveyed by rail, is subject to the higher tariffs, thus leaving the lower-rated traffic to the railways. As the high-rated traffic whilst representing only 16 per. cent. of the tonnage of goods conveyed by rail nevertheless earns approximately 60 per. cent. of the total revenue from goods traffic, unrestricted road competition would have a very serious effect upon the finances of the railways.

SUDAN RAILWAYS.

See reply to question 5.

QUESTION 12.

What is the present (and the pre-war) average cost per passenger/km and ton/km carried by the railway, including sinking fund charges? What method do you follow as regards this sinking fund?

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

An equitable method of distribution of cost per passenger/km and ton/km is now under examination. An *ad hoc* method of division on the gross ton mile basis used to be done for compilation of these statistics in earlier years, but an attempt is being made now to arrive at more accurate figures.

SOUTH AFRICAN RAILWAYS.

The present and pre-war average cost per passenger journey and per freight ton mile of goods carried are as follows :

	Present (1948-1949)		Pre-war (1938-1939)	
	s	d	s	d
Cost per passenger journey	1	5.60	1	8.12
Cost per freight ton mile (goods) . .		.7642		.5587

Passenger-mile statistics are not taken out on the South African Railways.

The foregoing figures include interest on capital and contributions to the Renewals Fund. Contributions to the Renewals Fund form a charge against working expenses and are based on the estimated average lives of the various classes of assets.

SUDAN RAILWAYS.

	Cost per mile Coaching		Cost per ton mile Pence
	s	d	
1935	9	10.5	.522
1936	10	1.5	.510
1937	10	2.6	.542
1938	10	9.9	.580
Average pre-war	10 s	3.3 d	.539
1946	17	1.0	1.065
1947	17	1.4	1.009
1948	24	0.3	1.234
Average	19	1.3	1.102

Receipts from passengers are comparatively small and at this stage it is not considered necessary to abstract passenger kilom. figures.

Sinking Fund charges are comparatively small and are not included in arriving at the above costs.

QUESTION 13.

What are (and what were pre-war) the costs of road transport taking into account capital depreciation?

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

No answer.

SOUTH AFRICAN RAILWAYS.

Cost of road transport, taking into account capital depreciation :

Post-war (1938-1939) 17.6 pence per car mile.

Pre-war (1948-1949) 27.9 pence per car mile.

SUDAN RAILWAYS.

Apart from transporting passengers on the Juba-Nimule road, a distance of some 120 miles, this administration undertakes no direct road transport. Goods on the same road are carried by contractors.

QUESTION 14.

When the road costs are the most favourable, have you considered suppressing railway services?

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

This has never been the case in India

SOUTH AFRICAN RAILWAYS.

No.

SUDAN RAILWAYS.

No (see reply to question 13).

QUESTION 15.

What advantage would it be from the cost point of view for the railway to give up all the lines showing a deficit? Do you consider that the railways might be able to meet road competition in this way without any other protective measures.

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

Does not arise in view of answer to question 14.

SOUTH AFRICAN RAILWAYS.

Branch Railway lines are not an alternative to main lines and branch lines cannot therefore be diverted to main lines. It may be mentioned that the South African Railways Administration itself operates an extensive network of rural and inter-urban road motor services covering a route mileage of over 25 000 miles and such services play the part of branch railway lines in developing areas which do not justify the expenditure involved in the provision of railway facilities. It is logical, therefore, that should the necessity arise for the abandonment of unpayable railway lines, the Administration which operated such lines should be given the opportunity of substituting road services.

Please see also reply to question 8.

SUDAN RAILWAYS.

Does not apply, see reply to question 5. There are no small branch lines as are found in thickly populated countries.

QUESTION 16.

What consequences would the possible suppression of the deficit showing lines have on the main line traffic? Up to what point would these consequences justify maintaining part of the deficit showing lines in service?

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

Generally the main line is not affected to any appreciable extent.

SOUTH AFRICAN RAILWAYS.

As branch line statistics are no longer maintained on these railways, it is not possible to furnish an answer to this question.

SUDAN RAILWAYS.

Does not apply (see reply to question 5).

QUESTION 17.

In what way do you think it would be possible to divert to the main lines the traffic from deficit showing lines which it has been decided to abandon?

Should the railway itself operate these road services? If so : directly or by means of an affiliated company under its control?

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

Such traffic can be diverted through an affiliated road transport company in which a railway is a financial partner.

SOUTH AFRICAN RAILWAYS.

Please see reply to question 5.

SUDAN RAILWAYS.

Does not apply.

QUESTION 18.

Do you consider that the arguments generally brought to bear against closing down deficit showing railway lines could be refuted if the railways organised corresponding road services, covered by the same legal regime as railway services, and if they adopted the same rates and granted the same reductions?

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

Although railways favour the organization of such road services in which they have financial interest, it is not economical in this country to reduce road rates to the level of railway rates.

SOUTH AFRICAN RAILWAYS.

The reply is in the affirmative. It is not the practice on these lines, however, to levy rail tariffs in such cases.

SUDAN RAILWAYS.

No answer.

II. NEW LINES.

QUESTION 19.

Have any new railway lines been built in your country since 1944 (if so, please give the length, operating regime, purpose, etc.)?

See table I.

QUESTION 20.

Are any lines under construction or proposed? (Please give the length, operating regime, purpose, etc.).

See table II and III.

QUESTION 21.

If the answers to question 19 and 20 have been in the affirmative, please state if the construction of these lines was decided upon for economic or other reasons.

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

In most cases the construction of the lines was decided upon for economic reasons. In a few cases, however, such as the Assam Rail Link, etc., the construction of the lines was decided upon for other reasons, mainly administrative.

SOUTH AFRICAN RAILWAYS.

All the above lines were authorized for economic reasons to meet expansion of traffic and new developments of a substantial nature and were recommended by the Railway Board.

SUDAN RAILWAYS.

Does not apply.

QUESTION 22.

Have considerations of general and national economy had a predominating influence, apart from the expected returns of the undertaking? What motives of national economy led to the new lines being built? What financial returns are expected?

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

Before undertaking the construction of any project, investigations are first made to determine how the proposed line will fit in with the general scheme of future railway development and what approximate return it would yield on the probable capital expenditure. Ordinarily only such lines as are expected to be financially remunerative are constructed, but in certain cases even unremunerative lines are constructed where they are essential either for administrative reasons or for agricultural, industrial and commercial development of the country. There are undeveloped areas in the country which are rich in resources such as coal, minerals, forest produce, etc., which can be explored or exploited only when a rail

TABLE I.

Section of line	Length in miles	Purpose
Indian Government Railways.		
Rupar-Talaura	34	The line was required by the Punjab Government primarily for the transport of materials, plant and machinery for the Bhakra Dam Project across the river Sutlej for irrigation and generation of electricity. The line will also assist in the development of the hilly tracts.
Bhimsen-Khairada	73	This line was dismantled in 1941 to meet an urgent military demand for track material. The restoration of the line was necessary in view of the developments in the area and also as giving an alternative connection between G. I. P. and E. I. Railways in the event of breaches or other causes on the Jhansi-Kanpur Section of the G. I. P. Railway.
Mudkhed-Dhanora . . . . . Section of the Mudkhed-Adilabad line.	54	The object of this line is to develop the extensive mineral, forest and agricultural resources of this region in the interior of the State and to connect up the important town of Adilabad.
Mavli Jn. -Bara Sadri	51	The object of this line is to open up rich forest areas and other fertile tracts of land.
Kanalus-Sika.	9	This branch is intended primarily for the development of the new Port of Sika but will also serve an area covering industrial villages and towns.
Jalahalli Branch . . . . . . (Bayyappanahalli-Jalahalli)	10	The branch provides rail connection between the main South West line (Madras Bangalore) of the M. & S. M. Railway and a new colony at Jalahalli.
Dahimsara-Malia	15	The object of this line is to connect Malia with Morvi and the port of Navlakhi.
Assam Rail Link . . . . . . (Kishenganj - Fakiragram)	140	Consequent on the partition of the country the new Assam Railway system ceased to have any direct rail connection with the rest of Indian Dominion except through Pakistan. It was, therefore, essential to provide a direct rail connection between Assam and the rest of India.
Sanganer-Phagi section of the Sanganer-Sawai Mangarh Line	22	Earthwork for this line was carried out in 1938 as a famine relief measure. The line is required for developing the country.
South African Railways.		
Village Main-Faraday. . . .	1	Extension of city terminal of native passenger line at Johannesburg.
Oogies-Van Dyksdrif	22	New line serving several new collieries in Witbank coalfield.
Whites-Odendaalsrus.	24	New line to initiate exploitation of new goldfield in Orange Free State Province.
Sudan Railways.		
No new railway lines.		

TABLE II. — **New railway lines under construction.**

Section of line	Length in miles	Purpose
Indian Government Railways.		
Barwadih-Sarnadih	40	This forms part of the 153 miles Barwadih-Bijuri project and is intended to open up new coalfields.
Kandla-Deesa	170	This is to provide rail connection to Kandla on the stretch of coast between Cutch and Kathiawar, where a new Major Port is being developed.
Mukerian-Pathankot	27	This has been necessitated due to partition of the country and will improve the transport facilities in the area.
Vijapur-Ransipur	14	The extension from Vijapur to Ransipur formed an integral link of the Vijapur-Vadnagar project of the Baroda State.
Pratapnagar-Dholka.	67	Will provide metre gauge link and improve rail communication between Baroda and Saurahstra Railways. Earthwork has been started as famine relief work.
Phagi-Sawai Mangarh section of the Sanganer - Sawai Mangarh line	54	Earthwork for this line was carried out in 1938 as a famine relief measure. The line is required for developing the country.
Dhamora-Adilabad section of the Mudkhed-Adilabad line.	47	The object of this line is to develop the extensive mineral, forest and agricultural resources of this region in the interior of the State and to connect up the important town of Adilabad.
Kanalus-Gop.	21	In addition to the ordinary traffic the line will carry raw material for a cement factory which is being erected at the new sea port of Sika.
Kirsadoh-Rawanwara	5	This branch will serve the coalfields.
South African Railways.		
Springs-Welgedacht	6	Avoiding line for goods and coal traffic in gold-mining area.
Kensington-Bellville	8	Avoiding line in Cape Town outer industrial and residential area.
Grootvlei-Redan	44	New line to convey 2 1/4 million tons of coal per annum to super power station of State Electricity Commission.
Van Dycksdrif - Broodsneyers-plaats	11	Further extension of Oogies-Van Dyksdrif line to serve additional new collieries in Witbank coal-field.
Sudan Railways.		
No new railway lines under construction.		

TABLE III. — **Proposed new railway lines.**

Section of line	Length in miles	Purpose
Indian Government Railways.		
Sarnadih-Bijuri	118	This will complete the through link between Barwaidih and Bijuri. The line will open up new coalfields and provide a valuable connection for movement of coal to the west, avoiding the already congested E. I. Railway main line.
Chunar-Robertsganj	—	This line is required by the Government of the United Provinces in connection with the setting up of a cement factory and for opening up a rich mineral area.
Champa Branch	26	This is required for development of new coalfields at Korba and setting up an aluminium factory by the Government of Central Provinces.
Kurla-Karjat	35	This line will provide a shorter route between Bombay and Poona and will open up Bombay from the East.
Kantabanji-Sambalpur. . . .	110	The line will serve the area to be developed by the Hirakud Multi-purpose Dam Project.
Rampur-Lalkua.	38	This line will serve the areas being developed by the Government of the United Provinces in connection with their colonization schemes.
Arantangi-Karaikudi	17	This will link an existing gap in the Railway system and provide a shorter connection to the South.
Thini-Gudalur	28	This line combined with the restoration of the Mathurai (Madras)-Theni portion of the Mathurai-Bodinayakanur dismantled line will provide the whole of the Cumbum Valley not only with direct railway communication with Mathurai but also Tuticoren, the nearest Port, and the whole of north via Dindigul.
Kandla-Jhund	131	This is required as the result of the Government of India's decision to connect by both Broad and Metre Gauge lines the Kandla Port which is being developed as a Major Port.
Jaisalmer-Pokran	65	This is required to improve the transport facilities in the area.
Phalodi-Kolayat	65	This is required to improve the transport facilities in the area.
South African Railways (*)		
Rangeview-Natalspruit. . . .	13 3/4	By-pass line to avoid hauling heavy traffic and coal through Rand mining area.
Vereening	1/2	Local by-pass line between two main lines.
Maitland-Observatory	3/4	Local by-pass line between main lines to Cape Town.
Vels St.-Bloemspruit	4	Local avoiding line between two main lines at Bloemfontein.
Sudan Railways.		
No proposed new railway lines.		

(*) The railway lines are authorised by Parliament and awaiting construction.

link is established. In the majority of such cases, no financial justification exists or can exist at any rate in the first phase of development. For the purpose of financing such projects which are necessary for the economic development of the country but are unremunerative at the time of construction, a Development Fund is being created. This will be in addition to the Revenue Reserve Fund and will be fed from the surplus revenues of prosperous years.

In regard to the financial returns expected, it is considered that for remunerative projects the net returns after making due provisions for depreciation, operation and maintenance should not be less than 4.25 % of the capital cost.

SOUTH AFRICAN RAILWAYS.

The statutory provisions governing the State-owned railways and harbours system of the Union of South Africa require that the railways, ports and harbours shall be administered on business principles, due regard being had, to agricultural and industrial development within the Union and the promotion by means of cheap transport of the settlement of an agricultural and industrial population in the inland portions of all provinces. Further, the total earnings of the system shall be not more than are sufficient to meet the necessary outlays for working, maintenance, betterment, depreciation and the payment of interest on loan capital. Every proposal for the construction of a new railway must be submitted for authorisation by Parliament together with a report thereon by the Railway Board which shall advise whether the proposed railway should or should not be constructed. The report is required to set out the estimated financial results of the line, if a new railway, or the justification for avoiding lines, etc., where provided locally to relieve traffic congestion.

SUDAN RAILWAYS.

Does not apply.

QUESTION 23.

With the cost of railway and road traffic as they are at the present time, in your opinion what volume of traffic is necessary if the construction of a new railway line is to be a paying proposition, taking into account interest on the capital invested?

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

Such volume of traffic as to earn the interest on capital invested plus a reasonable profit.

SOUTH AFRICAN RAILWAYS.

It is the policy of the Union Railway Administration, which operates a large rural road transport network, that road motor transport shall be used for the development of outlying areas until such time as it can be established that road transport can no longer meet the requirements satisfactorily in an economic manner in comparison with rail transport. The question of when this situation would arise depends entirely upon the nature of the traffic, its competitive market price and the influence of the length of the road haul upon the successful marketing of the commodity. Coal, ores and other bulk minerals, for example, must necessarily be dealt with by railway transport, subject to the volume of such traffic being sufficient to cover the expenses of any proposed railway with due allowance for the initial period of development and expansion of the industry.

SUDAN RAILWAYS.

Not possible to reply to this question, as many factors, other than economic, would have to be taken into account if construction of a new railway line were to be contemplated. No new lines are envisaged at the present time.

QUESTION 24.

What methods can be adopted to determine the probable traffic on a new railway line, supposing that sufficient statistical data are available concerning the economic situation of the district concerned? To which statistical data do you attach the greatest importance?

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

The produce both agricultural and industrial is ascertained. After allowing for local consumption, the difference is taken as the import and export traffic. From the existing movement by road, the destination is ascertained. Statistics furnished by Government bodies are taken into consideration.

SOUTH AFRICAN RAILWAYS.

It is the practice of the Union Railway Administration in examining the economic possibilities of proposed new lines, to have comprehensive local enquiries made by commercial officers of its staff, and also to obtain reports from all the Government Departments concerned, such as the Departments of Agriculture, Forestry, Mines, Irrigation, Land Settlement, Native Affairs, Commerce and Industries, etc. The Union Government has recently established a Natural Resources Development Council to advise it upon regional development in collaboration with Regional Development bodies.

It is considered that statistical data covering all classes of production and development are necessary in examining the possibilities of new lines.

SUDAN RAILWAYS.

See reply to question 23.

QUESTION 25.

What characteristics of an important traffic, concentrated in given periods of the day, week or year, in your opinion would make it necessary to build a new railway line?

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

Long distance traffic in sufficient volume.

SOUTH AFRICAN RAILWAYS.

As indicated under (23), given sufficient volume of production, railway transport is essential for coal, ores and bulk minerals of low value, and also (outside varying short limits of economic road haulage distance) for rough timber, grain and other agricultural produce in bulk, bricks, cement, and many other similar commodities. The whole matter is, however, bound up with the economics of competitive production and where existing producers enjoy rail transport facilities at low tariffs far lower than normal road transport charges, new producers would need similar aids in order to compete effectively.

SUDAN RAILWAYS.

See reply to question 23.

QUESTION 26.

Are you of the opinion that road transport has already reached such a stage of development that it can deal with transport in bulk?

ANSWERS.

INDIAN GOVERNMENT RAILWAYS

Not in this country.

SOUTH AFRICAN RAILWAYS.

The Union Railway Administration's road motor services are handling all classes of traffic in large tonnages, including livestock and for reasonable distances in serving outlying centres, conveying coal, ores in bulk, timber, etc. As, however, road transport costs are far higher than the tariffs applying by rail for a wide range of low-rated commodities, including live-stock, there is a definite economic limit to the extent to which road transport can displace rail transport upon an economic basis.

Road transport is capable of dealing with transport in bulk, but where a sufficiently large and constant volume of traffic is offering to warrant the capital outlay on a

railway line, the latter is the more economical proposition.

SUDAN RAILWAYS.

No.

QUESTION 27.

Taking into account the possibilities now offered by other methods of transport, can it be affirmed that nowadays the construction of new railway lines is essential to the economic development of a district and backward countries, and that investing capital in this way is the most economic solution from the national point of view.

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

To a certain extent the construction of new railway lines is considered essential to economic development and to this extent investment of capital in this way offers the most economic solution from the national point of view. The very high cost of railway construction, however, renders it imperative that new construction should be limited to those areas where it is absolutely essential and should only be undertaken after the possibilities now offered by other modes of transport have been fully assessed.

SOUTH AFRICAN RAILWAYS.

As stated under (23) it is the policy of the Union Railway Administration to promote the initial development of outlying, undeveloped or backward areas by means of road motor transport conveying those items of production for which road transport costs are economically practicable. Under the present relative level of road transport costs and rail transport costs, railway transport facilities would normally become essential in due time if the full productive capacity of a district is to be promoted but depending, of course, upon what it is capable of producing.

SUDAN RAILWAYS.

See reply to question 23.

QUESTION 28.

If so, what form of management should be set up? How should relations with the State be regulated : either as regards the financial needs of the new lines, or as regards subsidizing the future operation of these lines if necessary?

ANSWERS.

INDIAN GOVERNMENT RAILWAYS.

Nationalisation.

SOUTH AFRICAN RAILWAYS.

The Union of South Africa has concentrated from the earliest period upon the State ownership of its railway and harbour facilities as the best means of promoting the national welfare. Actually, it was forced to do so by the hesitation of private interests in facing the financial risks involved in the earlier period of sparse population and uncertain prospects.

SUDAN RAILWAYS.

Does not arise.

As the question 29 and 30 are limited to those countries which suffered war damage, they do not concern India, South Africa and Sudan.

PART II.

SUMMARY.

My former report dealt with replies to the questionnaire from railway administrations in U. S. A., Great Britain and New Zealand. This report will include countries such as India, South Africa and Sudan. These countries still have wide areas to be developed. The problems in the railway policy are therefore more attached to the construction of new railway lines than in the countries dealt with in the former report.

The operating budgets of the railway companies concerned have in most cases shown a surplus.

Where India is concerned, the Railway Board in New Dehli has answered on behalf of the railway administrations in this

country. They have not given any particulars for the single railway administration, but in most cases the operating expenses exceed operating receipts.

The Sudan Railways have had a surplus for the last two years as well as for the five years prior to 1939.

The South African Railways have had a deficit in the last two financial years and a surplus in the five years prior to 1939.

In India and South Africa a deficit would be covered from accumulated funds, whereas the Sudan gives no particulars regarding the manner of covering an eventual deficit.

The Indian Railways are divided into separate units for each of which separate budgets are established. In the other countries concerned they do not set out partial budgets for the separate lines. However, in South Africa the operating results of certain lines are guaranteed by outside interests. Consequently, partial budgets are established for these lines.

As regards the possibility of improving the financial situation of the deficit showing lines, the Indian Railways answer that the rating policy is sufficiently flexible to provide for any adjustments that may be necessary The South African Railways on the other hand are precluded by legislation from applying a specific rating policy in order to improve the financial situation of a deficit showing line.

According to the answers, the railway administrations concerned are not seriously affected by road competition. In India as well as in South Africa the State try to co-ordinate the whole system of transportation, partly by means of nationalisation and partly by means of legislation. In most cases road transport is not permitted to compete with the railways for the long distance traffic.

The South African Railways give the interesting information that the high-rated goods traffic represents only 16 per cent of the total tonnage of goods, but represents approximately 60 per cent of the total revenue from goods traffic. As experience has shown that road transport is able to divert the highly rated goods from the railways, unrestricted goods traffic would have had an adverse effect on the economic conditions of the railways.

As mentioned above, the countries dealt with in this report still have wide areas to be developed. The development of the system of transportation is not yet finished. Therefore, they are still constructing new railway lines whereas the countries dealt with in my former report (e. g. U. S. A. and Great Britain) consider construction of new railway lines as ended.

The construction of new railway lines is mainly motivated in economic considerations. A few exceptions are made for railway lines constructed for administrative and other reasons.

In general, the Indian Railways claim that the net return should not be less than 4.25 % on the capital invested. But there are many exceptions to this general rule. For instance, if a railway line is to be built in order to exploit an undeveloped area with rich resources, and the line is not expected to yield a financial return in the first phase, fresh capital is drawn from funds fed by the surplus revenues of prosperous years.

In South Africa road transport is generally used in the first phase of the development of backward areas. A railway line would be built when road transport can no longer meet the requirement in an economic manner compared with rail transport. The solution of the problem in each specific case naturally depends on the volume and nature of traffic and other economic conditions.

The South African Railways give examples of merchandises which in their opinion are typically suited for rail transport. Such commodities are coal, ores and other bulk minerals.

As regards road transport, both India and Sudan are of the opinion that road transport has not yet reached such a stage of development that it can deal with transports in bulk. In South Africa on the other hand road transport is able to deal with transports in bulk, but where a sufficiently large and constant volume of traffic is to be conveyed, a railway line is generally the most economic solution of the problem of transportation.

[**656** .255]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

15th. SESSION (ROME, 1950).

QUESTION XV.

Signalling on single track lines.

REPORT

(Austria, Belgium and Colony, Bulgaria, Czechoslovakia, Denmark, Finland, France and Overseas Territories, Greece, Hungary, Italy, Luxemburg, Netherlands and Colonies, Norway, Poland, Portugal, Rumania, Spain, Sweden, Switzerland, Syria, Turkey and Yugoslavia),

by W. A. Vrielynck,

Ingénieur civil,
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and Paul Thomas,

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Ingéniéur du Service de la Traction et du Matériel de la Société Nationale des Chemins de fer Vicinaux (Belgique).

INTRODUCTION.

The questionnaire, which we drew up in agreement with Mr. H. W. Jackson, M. Sc., Chief Signal Engineer, South African Railways and Harbours, the Reporter on the same subject for English speaking countries, was sent to 81 Administrations and we received 37 replies. The following have informed us that they are unable to furnish any useful information, either on account of their circumstances, or the particular characteristics of their Railway systems, or because they do not operate any light Railways or colonial lines :

— French National Railways Company;
— Paris Transport Board;
— General Light Railways Company;
— Belgian Light Railways and Industrial Company;
— Viege & Zermatt Railway;
— Swedish State Railways;
— Swedish Private Railways Association (Nora-Bergslag, Nordmark - Klarälven, Nora - Ostergötland, Oxelösund - Flen - Westmanland, Stockholm-Roslagen);
— Spanish National Railways;
— Mediterranean-Niger Railway;
— Damas-Hama and Extensions Ry. Company;
— Dutch Indies State Railways;
— Dutch Indies Railway Company.

The *Lower Congo and Katanga line* advises us simply that up to the present it has used the Webb and Thompson electric train-staff exclusively on signal lines.

The *Danish State Railways* say merely that their single line routes total 1 798 km (approx. 1 100 miles) and that there is only one section of about 8 km (approx. 5 miles) worked by a manual block appa-

ratus, all the other single line sections being operated by station to station messages, the small amount of traffic carried not justifying the adoption of ordinary signalling.

The *Rhaetian Railways* have not given us any information on their single line signalling.

The other replies have been grouped in the annexed tables and will be referred to in the report as occasion arises.

CHAPTER I.

General considerations.

The object of Railway signalling installations is to enable the traffic to be conducted with regularity and safety, and these conditions apply equally to light Railways or main lines.

In the case of light Railways or colonial lines it is essentially the signal systems in use on single line sections that call for attention, and we are concerned here only with those installations.

It follows as a matter of course that the method of signalling adopted depends on several factors, of which the principal are :

1) the importance of the Railway concerned;

2) the length of the single line sections;

3) the length of the loops;

4) the frequency of the train service;

5) the speed of the trains;

6) the type or types of traction used;

7) the costs the line is able to support in this connection.

Tables I and II enable the position to be ascertained with respect to each of the companies.

Table I summarises and sets out the particulars sent to us regarding the importance, the character, and the general circumstances of the various Railways and their single line sections.

Table II gives a general view of the operating characteristics of the lines (method of traction, make-up of the trains, speed, frequency of the services, etc.) and the kind of signalling used, or in contemplation.

CHAPTER II.

Single lines signalling systems.

We may note here that it has been agreed to define as « *single line section* » *the entire portion of single line comprised between two sidings or loops, or stations, where trains can meet and cross one another.*

A signalling system installed on such a section has of necessity to ensure that the traffic shall pass from one crossing place A to another B, and vice versa, with ease and regularity, with all the safety necessary and at the minimum of expense.

We shall call this ordinary normal case « *single line signalling in two directions* ».

It may happen however that in certain particular cases of working a branch line connection (a secondary track towards a shed or workshops, a quarry or some agricultural centre, for forestry or otherwise) joins the main single line between the points A and B, and serves a centre C which may be a siding, a station or a dead-end line.

We are thus led to consider this particular case which we shall call « *single line signalling in three directions* ».

Signalling of this kind must be able to work with safety traffic from A to B, B to A, A to C, B to C, C to A and C to B.

We shall consider each of these cases separately.

CHAPTER III.

Single line signalling in two directions.

We can classify signalling systems in different ways, distinguishing between those

requiring staff to be on duty at fixed points, or those worked by the train crews themselves, or automatically by the passage of the train.

A second classification would be made according to the principle on which the system is based and we should distinguish between those which employ a train-staff or token of some kind, the telephone, or electric light signals, intercontrolled in some manner.

A third classification would be one taking into account the costs of installation, or the costs of working, or again the entire costs including the interest and depreciation on first cost and the operating expenses. A fourth would be based on the speed of operation of the equipment, which comes down in effect to the time taken to cross two trains.

If we take into account the basic principles involved we have to distinguish between :

Signalling systems using a train-staff (or token) :

1) the ordinary train-staff systems, with shuttle service;

2) the electric train-staff system.

Telephone working :

3) by a supervisor or traffic controller, superintending the whole working of the line;

4) by telephone block working;

5) by actual block apparatus;

6) *signalling by means of light signals electrically interconnected and controlled;*

7) *certain special or simplified signalling arrangements.*

The arrangements mentioned under 2, 3, 4. 5 and 7 necessitate the use of numerous staff at fixed points along the line. They are therefore costly to work, unless the persons concerned can be made use of to carry out other duties as well.

Those referred to under 3, 4, 5 and 6 are rapid in operation and do not give rise to loss of time when trains cross.

There is nothing absolute about the classification resting on fundamental principles. Variations have been made to meet the general character of the traffic working or the need for economy.

We shall describe briefly these various systems and mention the simplifications that have been introduced into them as occasion has served as well as the operating regulations used with them.

1. Signalling by ordinary train-staff.

This system, used on certain single line sections of the Algerian Railways, is the simplest that can be imagined. It offers however a sufficient degree of security under certain working conditions with light traffic. The loops and stations have neither fixed signals nor point indicators.

Each section worked with a shuttle service has one single train-staff allocated to it, bearing on a copper plate the names of the stations at the ends of the section. Special instructions regulate the running of trains and light engines and any unusual movement requiring to be made, such as a change in the order of running of the trains, breakdowns, breakages of couplings and special cases of pilotage when there is any interruption to the track.

2. Signalling by electric train-staff. (Webb and Thompson System.)

Principle of operation.

This method of signalling rests on the fact that every train travelling over a single line section comprised between a station Gn and another Gn + 1 (or inversely) (see Fig. 1) must carry a staff taken out of a Webb-Thompson instrument B (or B1) at the station Gn or Gn + 1 and which, after the train has passed through the section must be restored to the apparatus B1 or B at the station Gn + 1 (or Gn).

The two instruments B and B1 form a pair and are connected electrically in such a way that by exchanging a conventional

set of messages and making appropriate movements combined with them, it is possible to withdraw a staff at B (or B1) after agreement between the two places, and impossible thereafter to withdraw another without having replaced the first in the apparatus, that is either at B1 or B.

The following conditions have to be fulfilled :

a) the withdrawal of a staff from one of the instruments B (or B1) before one previously withdrawn from one of them has been restored to the instrument B (or B1) from which it was taken or to the one working with it;

b) the simultaneous withdrawal of a staff from each of the two connected instruments.

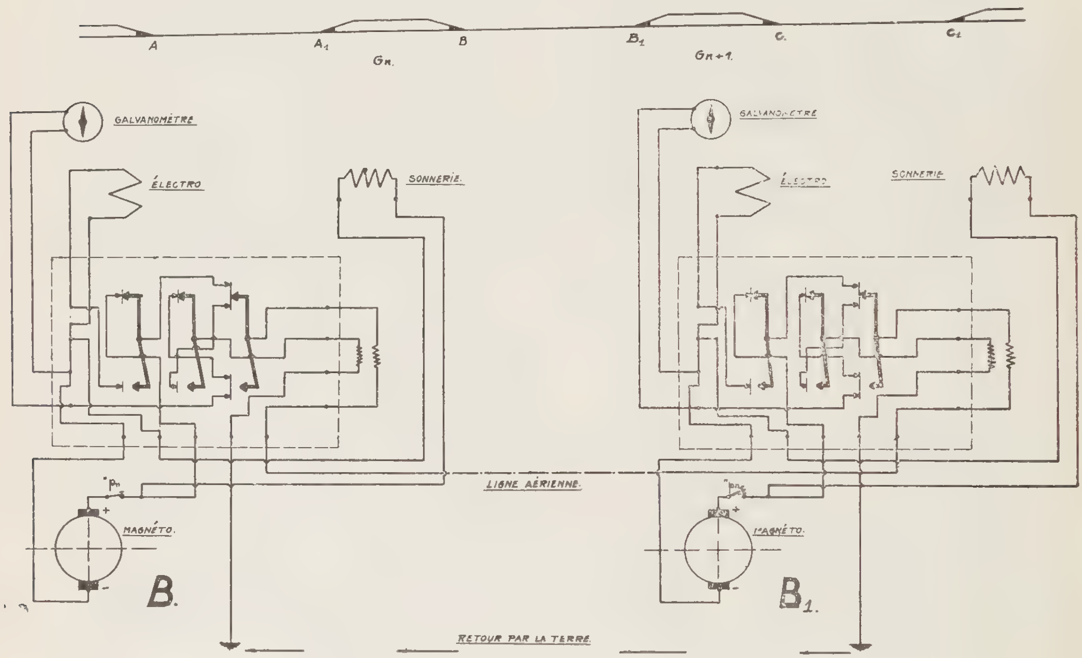


Fig. 1.

Explanation of French terms :

Galvanomètre = Galvanometer. — Electro = Electro magnet. — Sonnerie = Bell. — Magneto = Magneto-generator. — Ligne aérienne = Line wire. — Retour par la terre = Earth return.

1) a staff relating to a particular section Gn or Gn + 1 can only be withdrawn by the person in charge at a station Gn with the consent of his colleague at the other end Gn + 1 of the section, who gives it by sending the necessary electric current;

2) the following operations must in all cases be impossible to effect even though those concerned are agreed to do so;

Description of the Apparatus.

The Webb-Thompson staff instrument consists of a main frame, the lower part of which serves as a magazine to hold the staffs, while the upper portion contains the mechanical and electrical mechanism which controls the actual working of the instrument (*see Fig. 2*).

At the top left-hand part of the instrument is the opening where staffs are

inserted and the quadrant shaped slot which they must pass along before reaching the magazine.

The later types of apparatus have an electrical indication which causes one of the two following signs to appear according to circumstances :

« Staff out, line blocked », or

« Staff in, line clear ».

A galvanometer needle serves to give

Layout and method of operation.

Fig. 1 shows the layout of a single line comprising a certain number of loops Gn, Gn + 1, etc., dividing the route into single line sections.

Let us suppose that station Gn wishes to send a train to Gn + 1.

The following operations must be performed by the signalmen or other traffic

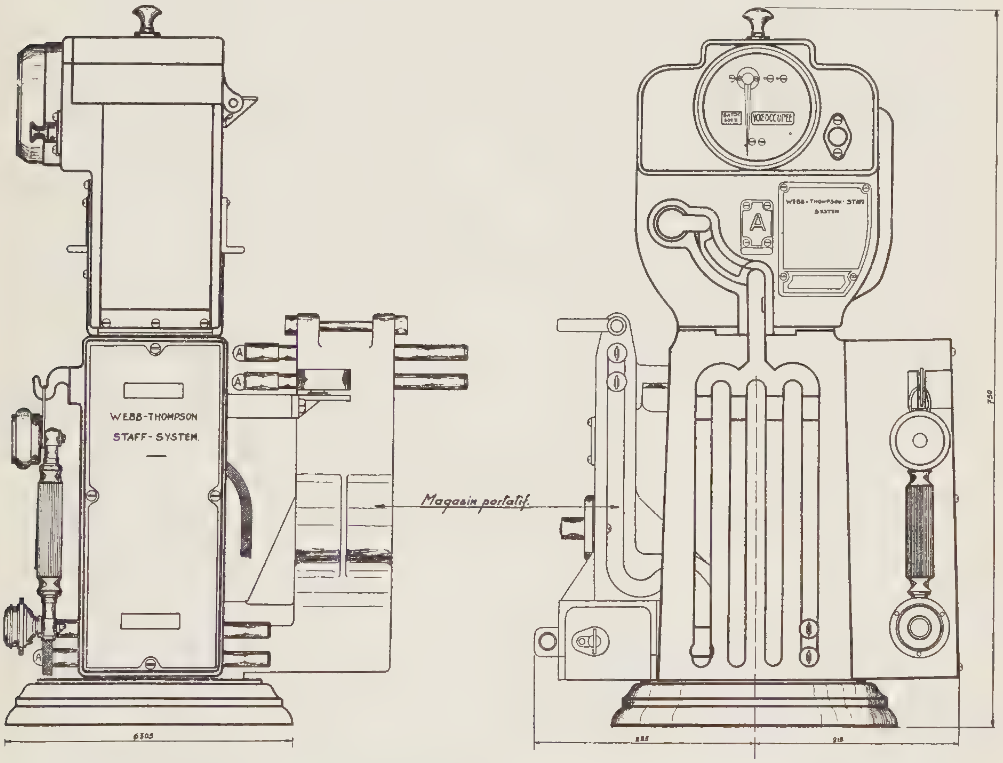


Fig. 2.

Explanation of French terms :

Baton sorti = Staff out. — Voie occupée = Line blocked. — Magasin portatif = Portable magazine.

certain indications made use of during the operation of the instrument.

A telephone working over the one-line-wire circuit connecting the two instruments completes the equipment. This is not used, however, in the course of normal operation.

staff by means of the magneto generators provided with the Webb and Thompson instruments, acting on bells or gongs with polarised movements and giving one stroke or beat only for each operation.

The transmission of signals takes place

in accordance with an exactly defined code, rendering any mistake impossible.

The operator (signalman, stationmaster, etc.) at Gn actuating the apparatus B referring to the section Gn/Gn + 1 sends a « warning » signal by turning the magneto and depressing the push-button « p » (see Fig. 1). The operator at station Gn + 1 acknowledges receipt of the signal by sending the same one in reply, if nothing prevents the desired traffic movement from taking place. Then the operator at Gn asks permission to withdraw a staff by sending three successive rings on the bell or gong, which is acknowledged by his colleague at Gn + 1 by a signal and by turning his magneto all the time his galvanometer needle shows that current is flowing and keeping his push-button « p » depressed.

During this time the operator at Gn goes through the process of withdrawing a staff and thereby brings about a one quarter turn in the mechanism which reverses the contacts in the apparatus, opens the circuit of the releasing electro-magnet and causes the sign « staff out — line blocked » to appear. The operator at Gn + 1, who continues turning his magneto, is notified of the completion of these operations by his galvanometer needle returning to zero.

The operator at Gn then sends two strokes of the bell to Gn + 1 to announce the departure of the train which causes the sign « staff out — line blocked » to appear also on the companion instrument B1 at that station, where the operator acknowledges receipt by one stroke on the bell.

On the arrival of the train at Gn + 1, the operator inserts the staff in the Webb Thompson instrument B1, relating to the section Gn/Gn + 1 and sends the signal « train arrived » by four strokes on the bell. This causes the indication « staff in, line clear » to reappear at Gn and when the operator there acknowledges by a stroke on the bell this alters the condition of instrument B1 and the same indication reappears there. The two instruments are now once more in phase and ready for another operation. The galvanometer serves to give a check on the performance of all these movements.

Fig. 3 gives a more exact representation of the manner in which the Webb-Thompson instruments are arranged along a length of line.

We remarked that each instrument had a magneto for carrying out the various movements at a loop station. There may however be only one, which can feed one or the other Webb-Thompson instrument alternately by means of two contact keys.

The turned steel staffs referring to adjacent single line sections are different. There are, in fact, six different types, the characteristics of which are given in Fig. 3. The instruments are so constructed as to make it impossible to insert a type A staff in one of instruments types B, C, D, E, and F, and inversely. To avoid multiplying the number of types, the instruments relating to neighbouring sections are different but on one single line railway line instruments of the same design may be met with several times, provided they are arranged alternately. In this way it is impossible to pass staffs from one section into neighbouring ones.

Apart from the rings on the staffs being arranged differently to distinguish the different types, all staffs carry four collars of like dimensions and similarly arranged. These rings are necessary to the working of the instruments. This precaution has been taken as a safeguard against staffs being carelessly made.

It has to be noted that this system of working involves the transfer of staffs from one signal box or station to another. As each instrument is provided normally with 15 staffs, if the traffic happens to be predominately in one direction, the magazine of one instrument tends to become empty and the other to fill up. To remedy this disadvantage there are devices known as

DIAGRAM OF LAYOUT.

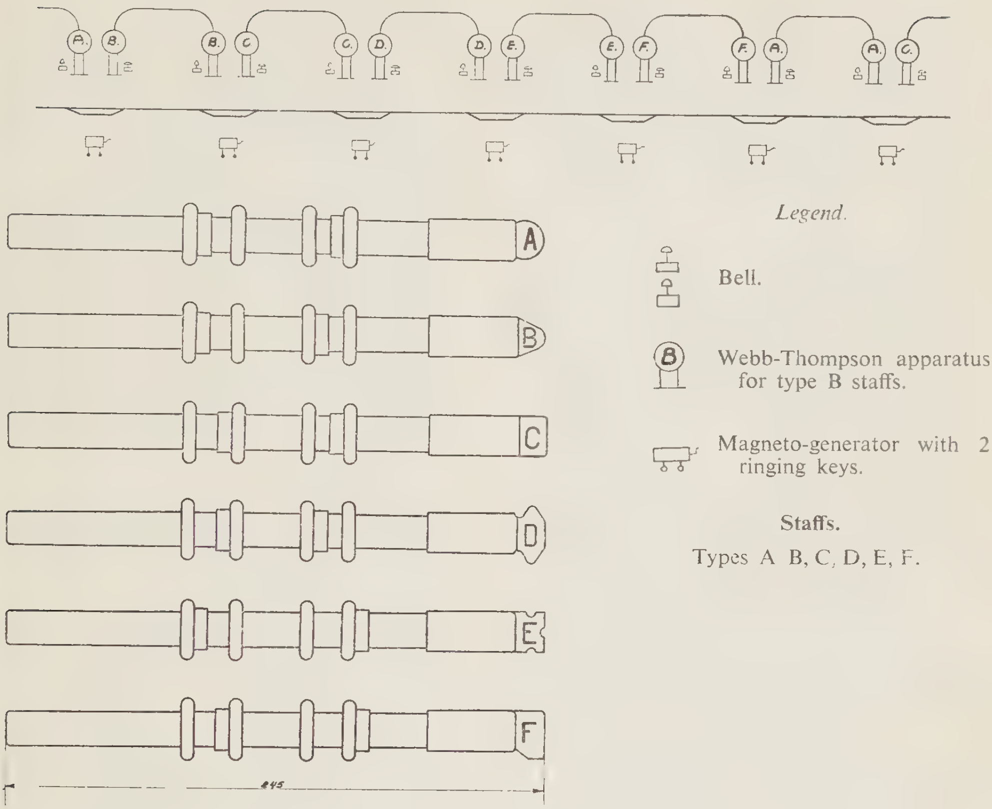


Fig. 3.

« portable staff magazines » (See Fig. 2) which can be fitted only to a certain definite pair of instruments (e.g. : pair A-A1, B-B1, etc.).

In the case of an unbalance of traffic, a staff magazine can be attached mechanically to one apparatus to permit the transfer of staffs from the magazine of the Webb-Thompson instrument into the portable one without having to interfere with the normal method of releasing staffs and without it being possible to withdraw a staff from the apparatus. The portable magazine having been filled can be unfastened from the instrument, taken to the other station, and secured to the companion instrument to enable its magazine to be replenished with staffs. In no case is it possible to withdraw a staff from the instruments themselves or from the portable magazine.

The Webb-Thompson system of signalling by electric trainstaffs, as described above, has been used for a number of years on the « *Chemin de fer du Bas-Congo au Katanga* » and by the « *Office d'Exploitation des Transports Coloniaux (Otraco)* ».

The latter company does not allow two or more consecutive trains to run simultaneously on a single track section of line, nor

does it permit a train which has entered a section to be turned back. In the event of the Webb-Thompson apparatus being out of action, traffic is controlled, by the « Dispatching » system, according to its order of entry into the given section.

These installations, which are manually operated by fixed staff, are entirely satisfactory.

Further details.

The system of signalling described above and known as the « Webb-Thompson train-staff system-absolute block system » is capable of being modified or varied to allow of greatly extending the traffic operating facilities afforded. The instruments can be worked both by dry batteries or accumulators.

It is possible with this system to allow several trains to travel with the required degree of safety in the same direction, at the same time and on a single line section.

If, for example, it is desired to send 2 or 3 trains in succession in the same direction, staffs composed of 2 or 3 portions assembled together are used. Each train takes a portion of the staff and the single line section can only be cleared again by the insertion of the complete assembled staff in the instrument at the outgoing end.

If however it is required to run more than 3 trains in the same direction at short intervals it is necessary to use the special counting or registering Webb-Thompson instruments, known as the « type S absolute and permissive miniature staff instrument ».

With these instruments it is possible to change at any moment from the « absolute block » — to the « permissive » system so long as the single line section is not occupied.

The system in question which is in use among other places in England, Ireland, Africa, Argentine, Brazil, Canada, Australia and China, offers the following characteristics :

1) it is simple and robust, all movements being mechanical except the actual locking which is electrically effected;

2) there are no relays, all electric contacts being actuated by mechanical means;

3) no special knowledge is required to keep the instruments working;

4) thanks to the use of a special piece of equipment known as « Whitaker's Automatic staff exchanger », the exchanging of train-staffs can be effected at a maximum speed of 90 km/h (56 m. p. h.) and it is not at all necessary to stop the train for such purpose;

5) in the absence of anyone at a station the train crews can themselves effect the operation of the instruments, as long as there is someone at the next station.

3. **Signalling by telephone under the authority of a traffic controller.**

Principles of working.

The line is divided into a certain number of sections known as « block sections » from one station to the next, whether intermediate or crossing.

Each station thus forms a block post and is provided with one or more telephone posts.

The supervisor of the line or traffic controller, on whom rests the responsibility for securing the safety of the traffic is connected to each of these posts by a separate telephone circuit.

At the crossing stations trains always take the left-hand line at the facing points, which are actuated by an ordinary direct acting lever and lie normally for that line, as seen by an approaching train.

The position of the points is indicated by a light signal fixed 50 m (55 yards) in rear, which shows a yellow light if the points are fully normal and a red light if they are in any other position.

At the intermediate or crossing stations the connections to the goods yard are kept locked and can only be unlocked by a key

in the possession of the head guard of the train; removal of the key locks the points.

Traffic working instructions.

The traffic controller is stationed at some selected point, generally at a terminal station or station at the end of a division; he has what are called block register books. Each of these rests in a frame below a diagram covering the section of line concerned.

Each head guard also has a block register book.

Immediately upon a train arriving at a crossing station and clearing the single line section the head guard reports the train's position to the controller by means of a pre-arranged code.

When the train is ready to proceed he asks the controller for permission to enter another block section.

This permission or a refusal is then communicated to him by telephone in accordance with the instructions in the code.

If after permission to enter the block section is received the train should be prevented (say by some failure or breakdown) from proceeding, the head guard must immediately inform the controller.

From this moment, the controller may not give permission to another train travelling in the same section to enter a block section occupied by the first train.

At stations, those shunting movements which occupy neither the section in advance nor the one in rear may take place at any moment.

Certain single lines of secondary importance belonging to the *Belgian National Railways* are worked on this principle, and this applies also to certain lines of the *Algerian Railways.*

On these lines, said to be operated under « complete control » the spacing of trains travelling in the same direction is taken care of by the traffic controller in accordance with clearly specified rules the principles of which are :

The traffic controller authorises the normal departure of a train only if the preceding ones travelling in the same direction have cleared the block section, that is the section of line comprised between a station or crossing place and the following one.

In the case of those trains which normally do not stop at certain stations and which in consequence have to run through several block sections in succession without stopping, the traffic controller may not give them permission to start unless the preceding trains have cleared the whole of the sections, which it is to run through in that manner.

If there is nothing to prevent it, the controller may under certain reserves authorise a train to enter a section already occupied.

In case of breakdown or the breakage of a coupling, the traffic controller may authorise a movement into the section occupied by the broken down train or the second half of the train that has become detached.

When there are signals at a station they are kept normally at danger. They are cleared (to allow a train to enter or pass through) under orders from the traffic controller. They must be replaced to danger immediately on being passed by a train.

From the moment when telephone communication with the traffic controller is interrupted and until it is re-established, the trains are allowed to run at sight, i.e. with caution, having the speed controlled so as to be able to stop short in the space of line seen to be clear ahead, and have to stop at all stations or crossing places, or sidings.

The railway system belonging to the « *Compagnie des Phosphates et du Chemin de fer de Gafsa* » is worked by a controller under similar regulations to those laid down for the Algerian Railways. A few stations only have outer discs and square home signals interlocked in a Saxby type signal box. The protection afforded by them is limited strictly to the station roads.

In addition discs made of metal are used, painted red on one side and white on the other, able to turn round a vertical

spindle and stand at right angles to or parallel to the track. At night, they carry a lantern showing a red or a white light.

From the operating point of view, the regular crossing places of the trains are decided by the working timetable, in the case of regular or conditional trains; and in the case of special trains or service trains the crossing places are laid down in special notices issued to those concerned.

Each train has to carry a journal or sort of log book, which has to be endorsed at each crossing place by the stationmaster who indicates alongside his signature the number of the train or trains that are met.

No train is allowed to leave or run through a station unless an interval of 15 minutes has elapsed since the last train in the same direction; this may however be reduced to 10 minutes if the speed of the second train is less than that of the first one.

Instructions of a more particular nature cover the various cases that can arise in practice.

4. Telephone block working.

This system can be either very simple, in combination with some elementary type of station signalling, or be sufficiently complicated as to make an approach to being equivalent to a real block system.

Principles of working.

The instructions covering the movements of the trains are sent by telephone from station to station; signals — either mechanically or electrically worked, — protect the entrance to and outlet from the stations. So called « operating » and « signalling » regulations deal with the normal course of working and such special cases may arise.

We refer below to the various companies that use this type of signalling and shall analyse briefly, if necessary, the essential basic principles of the rules in force on these Railways.

The *Finnish State Railways* use at stations and crossing places mechanical type semaphore or light signals.

No train may leave and enter on a single line section unless the so-called « train reporter » at the station has advised the controller's office and the various telephone posts along the section which the train will pass and unless the preceding train has duly passed the first of such posts, should they exist.

The train reporter at a station who receives a train has to inform the controller's office or telephone post in advance. The switching out of any such post or control office has to be made known to the driver in writing.

Each train reporter has to keep a block register book.

Any starting signal or other signal indicating « line clear » must be at once replaced to « stop » on being passed by a train.

If a train has to be stopped at a control or telephone post not provided with a semaphore a « reduce speed » hand signal must be shown to it and must be acknowledged by a blast on the engine whistle, after which a stop signal must be given. To enable the train to start the person in charge at the post must verbally instruct the driver or show some conventional hand signal.

In any case, no train may pass such a point even through the signals there may be at « line clear » without receiving a « line clear » hand signal in confirmation showing that the person in charge has assured himself that the section is clear.

No signal may have its position altered or be put out of use without those interested being advised of the circumstance.

When a signal is put temporarily out of service it must have an « out of use » cross affixed to it.

On the lines owned by the « *Société Générale des Chemins de fer Economiques* », the spacing of the trains is effected by the aid of telephone or telegraph messages. All communications concerned, either directly or indirectly, with the safety of the service must be sent from station to station, either by the stationmaster or someone expressly appointed by him. The message form must

indicate the sending station, the receiving station, and exact time of transmission. These messages must be written down in addition at each station in a regulation register book, with date and times of transmission and receipt.

Special « regulations governing the running of trains and engines on single lines » provide for every case of running, crossing other trains, arrival and departure, the interval to be maintained between trains, the running of light engines, conditional or special trains, the reporting of delays and special cases of trains stopping, such as breakdowns and requests for assistance.

There are signals only at the stations.

Visual signals are either fixed or moveable, and audible moveable signals may be used.

The absence of signals indicates that the line is clear.

Fixed signals indicate either the proximity of stations where there is someone on duty all the time, or junctions or places where obstructions may be met with.

Signals at the approach to stations are formed of a square or round disc, or target, placed 1.50 m (4′11¹/₁₆″) above rail level, painted white with a border on the face turned away from the station. They order a reduction of speed to 15 km (9 miles)/h. for goods, mixed or engineer's trains and to 30 km (18 miles)/h. for passenger trains.

At night, a lamp gives a white light. At stations usually manned but which can be unstaffed at certain times, these lights are put out and the points are then padlocked.

Signals protecting the junctions and special places are formed of a target painted in red and white squares, able to stand parallel to or at right angles to the track; the latter position indicates « stop ». At night, a lamp shows a green light for clear and a red light for « stop ».

Yellow and red flags are used by day; at night or in foggy weather a lantern showing green yellow or red at will is used.

The flag rolled up round its stick (or a green light) indicates « line clear ».

The yellow flag (or light) indicates « reduced speed » and a red flag or light absolute stop.

Reduced speed signals are required to be shown or fixed 750 m (826 yards) at least from the point where the speed must be reduced.

« Stop » signals must be effected or placed at least 800 m (875 yards) before the point where the stop is prescribed.

Audible signals are given by whistle, horn or trumpet. The whistle is used by the stationmaster to give the signal to start or stop and the horn by the guard for the same purposes. The trumpet is used along the line to give notice of the approach of trains. A number of blasts in succession constitutes an alarm signal.

Shunting is controlled by flag, lamp, or whistle, or horn, or trumpet, under an agreed code.

Detonators, supplied to station, track and train employees, are also used, day and night, when the ordinary signals cannot be lighted or cannot be distinguished at least 100 m (109 yards) on account of atmospheric conditions. When they are used two are placed, one on each rail, 25 to 30 m (27 to 32 yards) apart. In damp weather three are put down as a safety precaution.

On the *Algerian Railways* there are various methods of signalling. Generally the telephone block is used. On certain single lines the traffic is carried on by spacing the trains under controller's orders or by using the ordinary train-staff, as above mentioned.

There are also variations regarding the signalling used, according to the type of station.

A distinction is made between stations which are not of ordinary type and are the object of special instructions as regards signalling and operating, and stations of the regular form, among these are :

a) stations where crossing loops are provided, but no semaphores;

b) similar stations but fitted with home semaphores;

c) stations of the « Est » type (former French Eastern Ry. type) interlocked by

« Bouré » key locking with or without home semaphore signals;

d) stations with the through or direct line arranged without any turnout, or « Ouest » type (former French Western Ry. type) with « Vignier » interlocking and « Bouré » key locks.

In the case of stations not fitted with semaphores, the manually worked signals are similar to those used on the Light Railways Company's lines.

At interlocked stations, the points and signals are interlocked by « Bouré » key locks, and the signals, points and bolts are electrically detected and repeated.

Special instructions cover the working in the case of the telephone communication being out of order and bring together the general and special rules referring to the safe working of the traffic.

On the « *Compagnie fermière des Chemins de fer tunisiens* » signalling is either very rudimentary or non-existent.

At « signalled » stations there is a red stop outer disc signal — « deferred stop » signal — placed at least 1 000 m (1 083 yards) in rear of the facing points, and this requires the train to proceed at such a speed as to be able to stop short of any obstruction or other signal. At stations where all trains must stop, this signal is a square red and white signal imposing an absolute stop.

If there are no signals a simple sign-post with the word « Station » is placed 100 m (108 yards) in rear of the facing points. This requires the driver to be prepared to stop short of any obstruction.

In any case, the train must stop before reaching the points which may only be passed over at ordinary walking pace, if a signal to draw forward is given, by waving a rolled up flag by day or a green light at night.

This very simple signalling is used only on lines carrying very light traffic, not more than 1 or 2 trains a day in each direction.

At night the red disc shows a red light when « on » and a white light when « off ».

The square stop signal shows two red lights, or a white light.

Should the disc not be working correctly it must be regarded as « on » and the driver informed of it at the previous station.

When a square stop signal cannot be changed from « stop » it can only be passed on a stationmaster's written order.

On the *Franco-Ethiopian Railway* from Djibouti to Addis Ababa the station signalling merely consists of a reduced speed signal in the form of a green disc 600 m (656 yards) in rear of the entrance to the station, calling for a speed of not more than 15 km/h. and an absolute stop signal in the form of a red disc. These red discs have a red light shown from an oil lamp.

Detonators are used with these signals or separately, to indicate that an absolute obstruction is to be expected.

The regular crossing points may be changed by the traffic controllers. A specially qualified man is stationed at Djibouti and controls the working on the section from there to Aicha, 145 km (90 miles). Another at Dire-Daoua deals with the sections from there to Aicha, and to Aouache, 400 km (248 miles). A third controls that from the last named place to Addis-Ababa, 235 km (226 miles).

On the *Madagascar Railways* discs, similar to those used on the Tunisian lines, are in use at certain important stations, operated manually and lighted at night.

The *Hungarian State Railways* use mechanical signals or light signals at stations. Special instructions are issued to cover the various working conditions that can arise.

The *Norwegian State Railways* use chiefly light signals and ordinary hand signals. The mechanical type signals now in use will be replaced progressively by light signals.

There is no standardised type of installation.

At stations without fixed signals, hand signals are given in accordance with special regulations.

Manually operated signals are worked exclusively by the station staff and the majority of them return automatically to danger when passed by a train.

The *Portuguese Railway Co.* uses mechanical signalling, with discs and semaphores, at its stations.

This system of signalling is being revised and a proposal to modernise the working is under consideration.

The principle of this is as follows:

a) main lines: single line and station signalling providing an absolute permissive block and interlocked signals;

b) secondary lines: stations signalled with outer home signals.

Light signals, giving three aspects, will be used exclusively on the main lines, and light signals or 3-position semaphores on lines of less importance but over which nevertheless some fast trains run.

Finally, on less important lines still, the present signalling will be retained.

The *Turkish State Railways and Harbours* use the telegraph for train working.

The station signals are mechanical.

The regular or altered crossings of trains may only take place at stations that are at the moment open.

Should telegraphic communication be interrupted, then time interval working is resorted to under the prescribed rules.

5. Absolute block working with telephone.

Principles.

A single line is divided into a certain number of block sections extending from station to station.

These block sections are protected by signals and the bolting and detecting of the loop facing points is effected by double-wire mechanical transmissions operated from the lever frame at the station.

At the end of each block section there is a block signal serving also as home signal for the station there and if this section joins on to a double line the signalling at the end of it is merged with the block signalling protecting such double line.

In the crossing or passing stations the starting signals protect the entrance to the block section ahead and the home signals mark the end of a section.

These signals are alike as to form and their meaning depends upon their position on the line. They are distinguished on the signalling diagram by appropriate symbols.

The single line stations generally have one through line which may be travelled over in either direction and a siding line used in one direction only.

There can also be a goods yard, served from either direction, as the case may be.

The facing points leading to the siding line are worked locally by a double-acting weighed lever, normally locked by a bolting piece controlled by key interlocking.

When the points are reversed they are bolted by a rotary type bolt lock worked from the lever frame.

The points at the other end of the station are taken trailing by departing trains, but are bolted by a similar rotary type bolt when taken by facing movements.

The entrances to stations are protected by stop signals, called block signals, at least 300 m (328 yards) in rear of the facing points, and preceded by distant or caution signals placed 800 m (875 yards) in rear on level track.

On that side where access is obtained to the siding used in one direction only, the semaphore block signal is fitted with a shunt arm admitting to such siding independently of the indication given by the home and distant signals.

A common block signals, for the two lines, controls the departure of trains.

This semaphore has a second arm controlling movements in the goods yard and the use of part of the single line in advance up to a fixed « limit of shunt » board 100 m (109 yards) from the home signal.

Generally at crossing and passing stations when trains do not have to meet or overtake they run in both directions over the through or main track.

Immediately the necessity to cross trains is notified, the facing points are set for the siding line by the man in charge of

them, and then bolted by the rotary bolt from the lever frame.

In certain of the stations, on lines of very light traffic, crossing can be effected without signals; in that case the approach to a station is indicated by a board painted black with three horizontal white stripes.

Fig. 4 shows the normal arrangements of the various types of signals for an ordinary well-known form of crossing station.

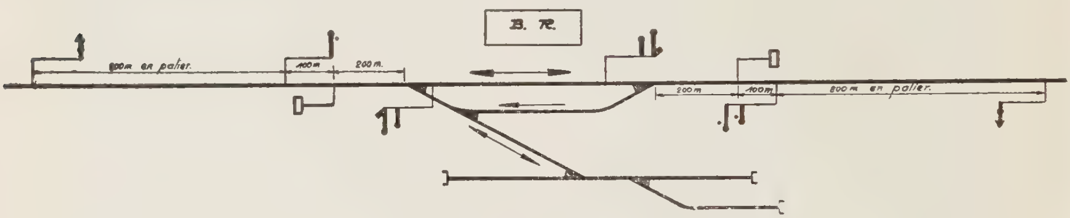
Working of the signals.

The working of the signals is under the control of the stationmaster.

He can give permission by means of :

a) electro-mechanical mechanism;

b) telephone messages in those cases where the place from which the signals are operated is separated from the booking office, where the stationmaster is stationed.



Explanation :

B. R. = booking office.

Warning signal.

Block section signal (entrance)

Signal, at end of block section.

2-arm signal (entrance of block section).

2-arm signal (end of block section).

« Limit of shunt » board.

Fig. 4.

When a single line section happens to be of exceptional length the block section can be divided into a number of shorter ones by placing intermediate block posts, but in practice only two such sections are provided.

A « block telephone » is provided at each block post in communication with the adjacent ones. The messages are entered in a block register, and a crossing station has two such, one for each adjacent section, but when there are two sections on the single line between stations the intermediate block post has only one register book.

If the signal operating is done from the booking office where the stationmaster is permanently located, the signalman and the stationmaster must both initial the entries in the block register book.

Operating instructions.

Where the signals are operated from some place away from the booking office and electro-mechanical apparatus is used for authorising the movements, such apparatus is kept normally locked by key locking, or is enclosed in a cupboard, the key of the lock or cupboard being kept by the stationmaster.

On the other hand, if telephone messages are used the levers or handles for the signals bear a red name-plate marked SL (slot) in white to draw the signalman's attention to the fact that permission to operate them must first be obtained by telephone.

Except in cases of extreme urgency, the stationmaster is prohibited from altering the route for a train once he has authorised the operation of signals for it.

After a train has left, he must see that it has been duly protected by the signals for the section.

If nobody is appointed to work the central apparatus the stationmaster himself deals with all messages; he also works the starting and home signals (fixed or moveable signals) as well as, when the case requires, the block apparatus. He issues the authorisations for the arrival and departure of trains. In that case the central apparatus has a lock and by removing the key from it the stationmaster is able to lock the levers in the positions they then occupy.

When no stationmaster is on duty, the block post should in principle be switched out, but if it must be kept open for traffic purposes, it can only be worked as an intermediate block post and must be in charge of a competent man.

Unless special instructions provide for it, the operation of the other fixed signals at a station is not subject to the special authorisation of the stationmaster.

Special instructions covering a divided single line section with intermediate block post.

Since there is no crossing loop at the block post a train must not enter the single line unless no other train is in the section beyond the block post travelling in the opposite direction. The regulations concerning the operation of the signals and the general instructions mentioned above are applicable.

Special instructions, beyond the scope of this report, deal with the following cases :

a) special train running right through the length of the single line;

b) special train not doing so;

c) temporary switching out of an intermediate block post;

d) similar switching out, while a train is in the section in the rear, or the section in advance:

e) switching in of the block post under the conditions given in (*c*) and (*d*) above.

The absolute telephone block working above described is that in use on the lines of the *Belgian National Railways.*

The *Greek State Railways* use a similar system with semaphores interlocked with the points, manually operated by wire and fitted with oil lamps.

Special instructions cover the case of absence of home signals, or home signals being out of order.

A home signal may only be cleared when the approaching driver has given a warning whistle showing he has his train under control.

The simultaneous entry of two trains, from the same or opposite directions, is not permitted as a rule, even where there are home signals.

In the exceptional case of two trains having to follow each other on a single line an interval of 10 minutes must be allowed between them, and the second trains speed be limited to 45 km (28 miles)/h. if it has automatic brakes or to 20 km (12 miles)/h. if not.

In this case too, the sending station must advise the next by telephone and in accordance with a form laid down the staff of the second train and that of the first train if possible.

If a train has to stop between stations the crew must protect it by hand signals at a distance varying from 150 to 1 400 m (164 to 1 530 yards) according to the gradient.

If, in exceptional circumstances, a train has to return to the starting station, it must do so at a walking pace and be protected by hand signals.

The guard must use the emergency telephone to advise the starting station of this.

The *Netherlands Railways* use the Siemens and Halske type lock-and-block apparatus on the main lines. On the electrified lines there is automatic block with light signals. On others, of a light railway character, that is where all trains stop at every station, the signalling is purely mechanical and the train movements are controlled by telephone.

In the case of « tramway » type traffic only the dangerous locations such as bridges, are protected by signals, and in certain cases traffic is controlled by the ordinary train staff system.

Certain special rules govern the operation of the trains. A starting signal may not be cleared before the train has been accepted by the next station.

No departure, arrival, entrance into a station, overtaking or crossing of trains may take place without a dispatcher's order.

Should telephone communication break down trains have to be run on sight.

No signal at stop may be passed unless :

a) a written order is filled up and signed by the chief signalman at the place concerned;

b) the train is taken forward by a pilotman;

c) the driver receives an order to move by telephone.

The seals of the block apparatus may only be broken on the authority of certain qualified officials.

The *Luxemburg Railways* use block apparatus with Siemens type electric interlocking, mechanical signal boxes using lever frames or « crank handle » frames, and mechanical signals with detector bolts on single lines.

Certain such lines of light traffic are however worked on what is called the « simplified » system, under which special instructions govern the train movements, and the crossing movements in the stations, fitted with semaphore home and starting signals.

The *Swiss Federal Railways* use signalling controlled by the « Siemens » or « Hassler » block apparatus, relay block apparatus type, or the continuous current « Hassler » or « Integra » types.

In certain exceptional cases the signalling consists of starting signals at the two ends without actual block apparatus between.

Mechanical or electrical signals are used, and distant signals in rear of the home signals at braking distance. Repeating lights are not used.

The power supply is 220 volts A. C. 16 2/3 cycles supplied by a 15 kV/220 V transformer connected to the traction network; a stand-by connection allows of the installations being fed from the local 220 volts, 50 cycles, supply in case of need.

Track circuits are fed at 12 volts and the operating circuits at 36 volts from trickle charged batteries.

Should the signalling have to be put out of service, the staff has to regulate the train movements by asking and obtaining line clear from station to station by telegraph or telephone.

If for any exceptional reason a train has to return towards its starting station on a single line it may only do so after receiving notice from that station.

On the *Emmenthal and Burgdorf-Thun* line the signals are either mechanical or of the light type, and the regulations are the same as those in force on the Swiss Federal Railways.

Particulars sent by the *Austrian Federal Railways* appear to indicate that they use the lock-and-block system. The signals are light signals, fed at 220 volts A. C. by day and 150 volts at night.

6. Signalling by means of light signals electrically interconnected and controlled.

Apparently the « *Société Nationale des Chemins de fer Vicinaux de Belgique* » is the only management using this system.

Its principal characteristic is that it is controlled automatically, using electric light signals fed directly at 650 volts D. C., either from the traction supply itself or through rectifiers specially provided for signalling purposes.

Principle of working.

A single line section between two loops *A* and *B* (or ends of double line sections) is protected by two lights, red and green, known as the main signal lights, placed at the loop points (the fouling point). A red supplementary approach signal occupying the single line and a white so-called « clearing proving » light, placed in advance at the opposite end of the section and included in the same circuit, is intended to inform the driver or motorman of the train of the extinction of the lights and hence the clearing of the section which the train has just left. « Repeating » lights are placed at intervals along the single line, formed of two lamps showing a green light in one direction and a red in the other. For each direction of running one only of these is lighted. These lights repeat the indication of the main lights.

There are thus two distinct circuits, one for each direction of traffic, formed normally each of eight special signalling lamps, 85 V., 40 W., connected in series.

If the section is unoccupied no light is burning.

In order to pass through a single line section therefore a train must first cause the signals to light up.

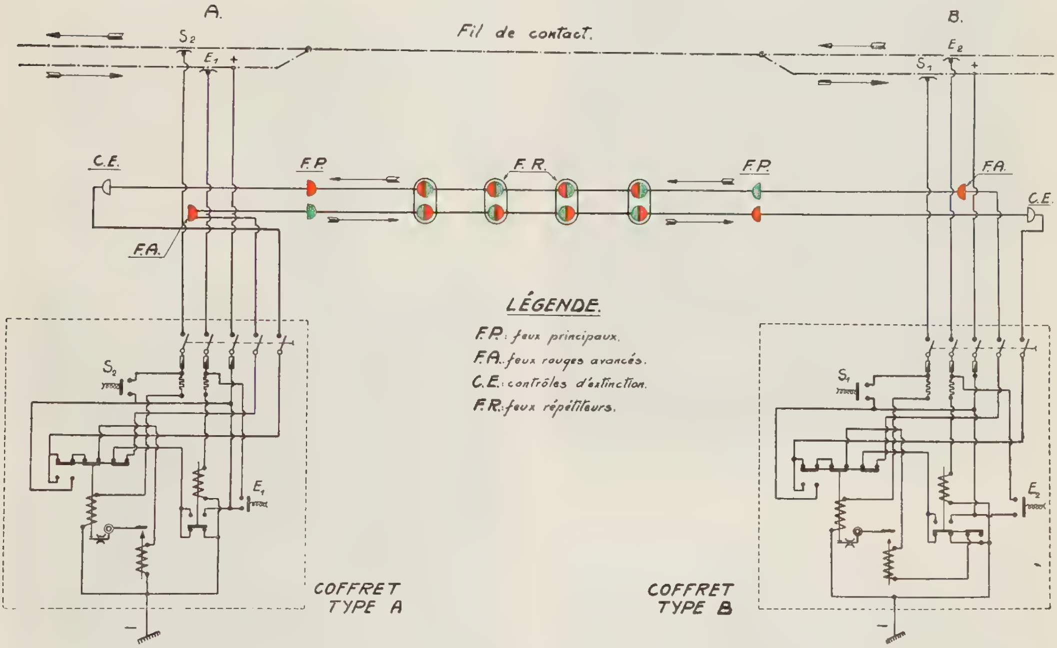


Fig. 5.

Explanation of French terms :

Fil de contact = Overhead contact line. — FP : feux principaux = Main signal lights. — FA : feux rouges avancés = Approach signal lights. — CE : contrôles d'extinction = Lights proving the correct switching out of the main lights. — Coffret = Apparatus casing.

Layout and method of working.

The layout of a complete installation with the relay cases (type *A* and type *B*) and the relative position of the signals with respect to the track are shown in *Fig. 5.*

Let us suppose that an electric train is to run from *A* to *B*. On passing under the

Fig. 6.

overhead contact *E*1, it must produce the lighting up of the green main light ahead of itself and all the repeating lights that are in series therewith, of which the green alone are visible to the driver. The red lights of these repeaters are only visible to a train travelling from *B* to *A*.

The train is now protected firstly by the additional approach red light F. A. placed in rear of it and no longer visible to the drivers of the train running from *A* to *B*, and secondly by the main red light at the other end of the section, visible when travelling from *B* to *A*.

A white light visible to this train running from *A* to *B* is lighted up at loop *B* in advance of the overhead contact *S*1.

On clearing the section *A-B* the train passes under this contact S1 which causes all the lights to go out, and the driver takes note of the extinction of the white « proving » lamp C. E.

If the section *A-B* is occupied by a train running in the same direction, the driver of the one which will in turn have to enter that section will see the approach red light F. A. burning, with the green main light and any of the repeating green lights within view.

If the section is occupied by a train travelling in the opposite direction, he will see the main red and repeating red lights burning, applying to the direction he requires to follow. In that case the train stops in rear of contact *E*1.

The red light is an absolute stop indication. A single line section equipment comprises :

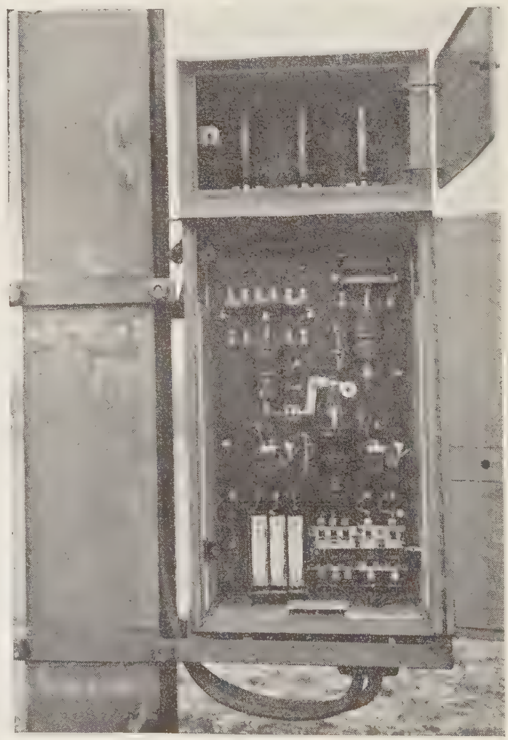


Fig. 7.

a) *two relay cases.*

Each relay case is made of teak wood, with a hinged door part. It contains two insulating base plates carrying the electric apparatus, relays, contacts, locking coil, manual control switches, main cut-out and fuses. It measures 630 × 400 × 180 mm.

At the upper part there is another case or box made of galvanised sheet steel, well provided with ventilation, measuring

Fig. 8.

Fig. 10.

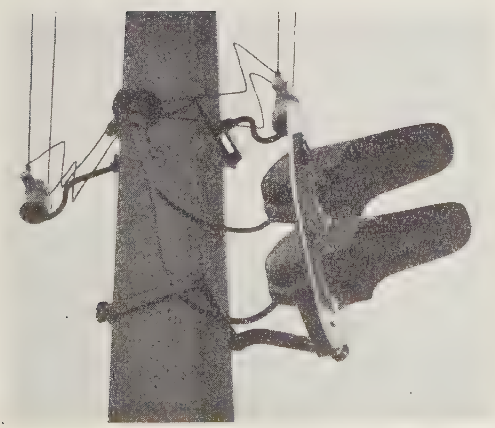


Fig. 9.

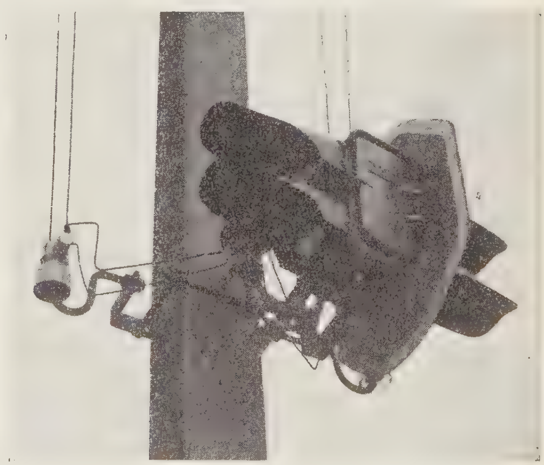


Fig. 11.

Fig. 12.

400 × 280 × 180 mm, containing only some additional resistances.

Fig. 6 is a photograph of the assembly attached to one of the overhead wire standards.

On the front face or door of the case can be seen the openings for enabling manual control to be effected and at the bottom of the side face on the right the handle for actuating the main cut-out, referred to below in the instructions for working the system.

Fig. 7 is a photograph of the same assembly with the doors open.

b) *signal lanterns of two types :*

1) the « ordinary » lanterns, of cast aluminium, with socket, lamp, chromium plated copper reflector, intended to produce an intense beam, a concave-convex lens with prisms on its internal face, made of clear red or green glass.

These lanterns are fixed to the overhead wire standard at 3.50 m (11′ 6 3/16″) above the rails and are fitted with hoods and a background plate of « simple » type (for the white « proving » light or the red approach light) or double (for the main red and green lights).

Figs 8, 9 and *10* show lanterns of these types.

2) « repeating » lanterns also in cast aluminium. Each contains two lamps and forms four light aspects. Each of the two lamps with its opposing light aspects forms part of a circuit corresponding to one direction of running.

The optical systems are formed of a Fresnel lens with a piece of red or green sheet glass and a fluted or stippled glass, intended to assist in preventing any « phantom » effect. In addition, each aspect is protected by a hood and the

Fig. 13.

lantern itself is fitted with a double-faced background plate (see *Fig. 11* for a photograph of this lantern).

3) line wires of 6 mm² (0.0093 sq. in.) cross section of the C. I. M. B. type;

4) overhead contacts of the blade type when the current is collected by pantagraphs or bows and of a special type when the ordinary trolley head is used (see *Fig. 12* for a blade type contact).

The length of the overhead contact is a function of the speed of the trains when passing the particular location, but is not in any case less than 1.50 m (4′ 11 1/16″).

Overhead contacts are not always provided; at certain dangerous points they are intentionally omitted in order to compel the train to stop. In that case the signals are operated by manual switches from the outside of the apparatus cases by means of a special key; the steam trains or internal combustion railcars running on the electrified lines make use of these switches which are connected in parallel with the overhead contacts.

Note. — The apparatus cases A and B are not identical as regards electrical connections. In the event of simultaneous operation at both ends of a section this ensures priority for the movement going from *B* to *A*.

This signaling is used on all the lines of the undertaking that are electrically operated. It will also be applied to a 50 km (31 miles) line worked by internal combustion railcars.

Part of this line has already been equipped. The control of the signals at present effected manually, will be made automatic by fitting the railcars and the entrance and exit to each section in the manner shown in the photographs *Figs. 13, 14* and *15*.

This system of signalling has been in use for many years and gives entire satisfaction.

It does not require any permanent operating staff. Nor does it occasion any loss of time when trains cross.

It requires no writing down and no

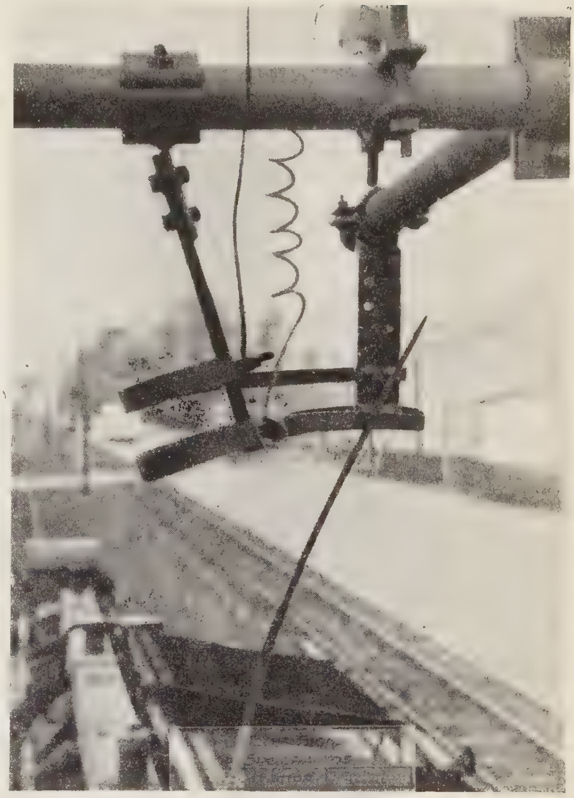


Fig. 14.

process of thought on the part of employees. It is completely foolproof in the sense that any failure, anything out of order, acts on the staff side.

The relays will function normally on any voltage between 450 and 750.

Train working instructions.

When a train arrives at the entrance to a single line section :

a) if the approach red light is burning and the others — the main and repeater lights — are green, the section is occupied by the preceding train running in the same direction; in this case the train stops in rear of the red light, according to rule.

Only under special orders issued by a responsible person may two or more trains follow each other in a single line section;

b) when a train is waiting in rear of a section occupied by the preceding train it must not pass under the contact at the entrance to that section, or operate the entering manual control, until at least 10 seconds after the extinction of the lights denotes that the section has become clear;

and advise other trains and the traffic controller or the nearest depot superintendent, of the circumstance by the quickest possible means.

If this has had to be done before entering on the single line, the train can only pass through the section under « piloting » that is to say the train must be preceded by an employee at a sufficient distance to be able to give a stop signal to any approaching train and thus protect his own train;

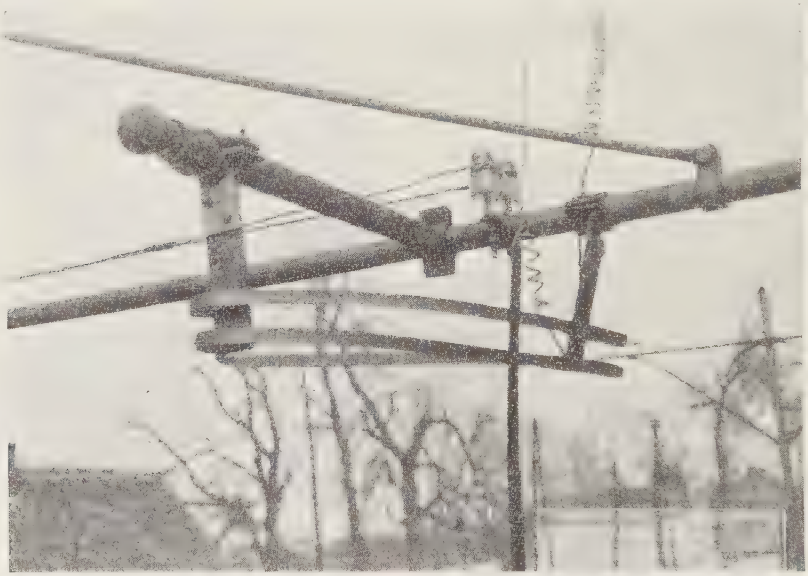


Fig. 15.

c) if the main and repeating lights are red, the section is occupied by an approaching train and the train must wait and cross it;

d) should the lights not light up or go out when the overhead contacts are passed, the corresponding operations are to be repeated by using the manual controls.

If nevertheless, in spite of these duplicate operations, it proves impossible to actuate the signals, the train must before entering on the single line or before leaving it actuate the signalling cut-out switch

e) when the operation of the signals has to be carried out manually, the guard makes the necessary operations and the motorman checks that he has done so;

f) if, in exceptional circumstances and under a special order, two or more trains have to pass through a single line section, the responsible person in charge of the last one has to see that the signals at the end of the section are duly operated.

7. **Simplified signalling systems.**

The *Réunion Railways* make use of a simplified signalling system, using hand signals (flags, either rolled up or displayed showing green or red by day, lanterns showing white, green or red by night) or audible signals (trumpets, horns, detonators). Fixed signals in the form of outer discs are provided to indicate the approach to stations and juctions and in particular all those places where an obstruction to traffic can occur.

In certain particular cases the following companies also make use of special simplified signalling arrangements :

« Société Générale des Chemins de fer économiques »;

« Algerian Railways »;

« Compagnie des Phosphates et du Chemin de fer de Gafsa »;

« Compagnie fermière des Chemins de fer tunisiens ».

Note. — We addressed to the various companies concerned the following questions :

I. What reasons led you not to generalise the application of signalling installations to all your single lines ?

II. What was the cost in 1949 of a single line signalling installation, assuming the section to be protected to be 1 km (1 093 yards) long ?

III. What are the annual maintenance charges on that assumption ?

IV. Do you ordinarily allow two trains to follow one another on a single line section ?

V. Do you allow that in exceptional cases ?

VI. May a train normally return to its starting station when in such a section ?

VII. May a train do so in exceptional circumstances ?

VIII. Are you entirely satisfied with your present single signalling ?

IX. Between what voltage limits will your single line signalling function normally ?

X. Do you use « repeating aspects » at intervals along the single line to repeat the indications showing at each end of it ?

XI. Do your signalling installations function automatically, that is are they controlled only by the passage of the trains themselves, or must they be operated manually ?

XII. In the case of automatic operation, is it supplemented by any emergency manual control ?

XIII. Have you any single line sections divided into more than two block sections by means of suitable signalling ?

The replies received to these questions are summarised in Table III; the numbers at the heads of the columns correspond to those of the questions given above.

CHAPTER IV.

Single line signalling for three directions.

The principal signalling systems dealt with above may be applied to the special cases where a single line has to be signalled in « three directions » as defined in Chapter II.

Details concerning these cases have been sent to us by the « Office d'Exploitation des Transports coloniaux », which uses the Webb-Thompson electric train-staff.

The « Société Nationale des Chemins de fer Vicinaux » uses an automatic signalling arrangement adapted to similar operating conditions.

A. *Signalling by electric train-staff.*

Suppose a single line section A-B has an intermediate point C where another line branches off.

In that case it uses at C a special Webb-Thompson instrument that differs from the normal type used at A and B in the following respects :

1) the galvanometer has two needles,

one connected with the instrument at A, the other connected with that at B;

2) the releasing electro-magnet is also in duplicate;

3) at C there is only one single magneto-generator.

branches off at point C, the train-staff must first be put in a lock placed in the operating apparatus working the switching point at C.

By working the point, the train-staff is locked and the train is taken over the

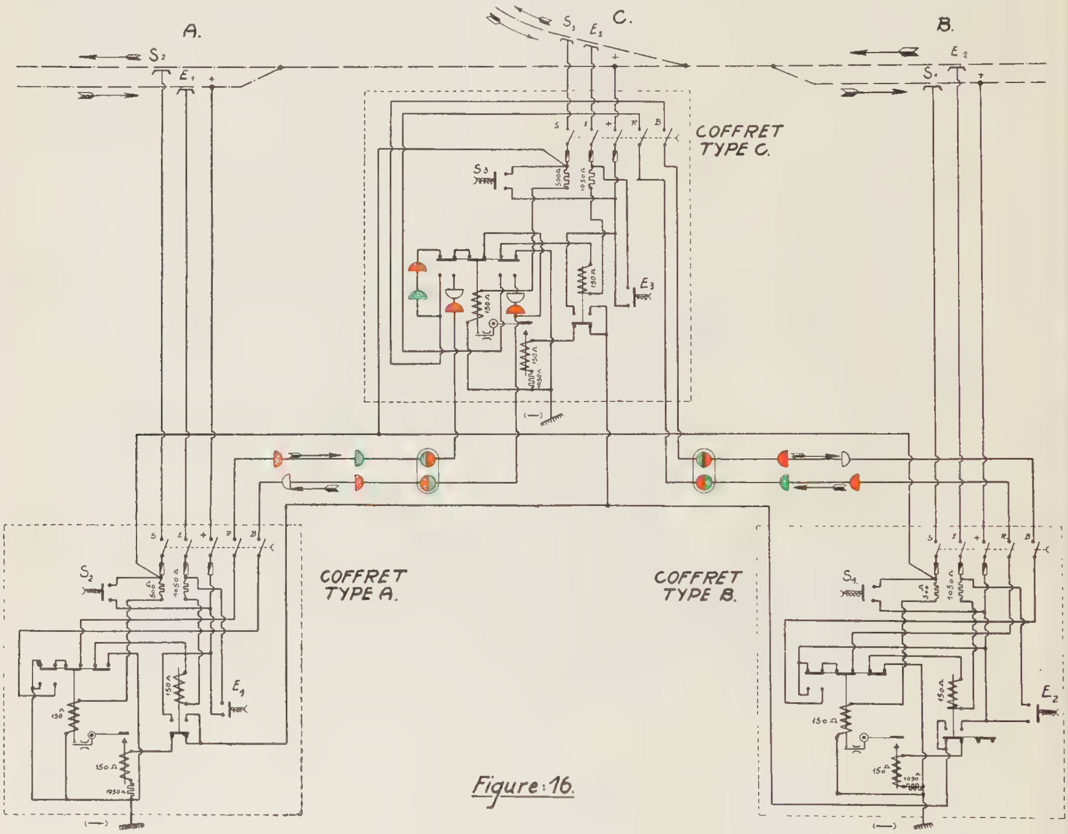


Fig. 16.

Explanation of French terms :

Coffret = Apparatus casing.

In addition A and C are connected by a second line wire which passes through the C instrument and is connected to earth beyond that point; the normal line wire between A and B also passes through C.

If a train has to enter the line, which switch. When the point is again in its normal position, the train-staff may be withdrawn and stored at C.

If, on the other hand, a train coming from the branch line at C has to proceed to A or B, it must first ring the bells at those places, this is done by actuating the

receiver at C. He is then in communication with A and B and requests permission to travel along the main line A-B. If it is permissible to do so, A and B send to C the current necessary to allow a train-staff to be withdrawn there.

All the other operations necessary are made in the normal manner.

B. *Signalling with light signals electrically interconnected.*

The layout of an installation of this type, used on the « Société Nationale des Chemins de fer Vicinaux » is shown in *Fig. 16.*

It will be noted that an assembly of this type comprises two apparatus cases similar to those described in Chapter III, and a supplementary one « C » substantially similar to them.

This signalling necessitates the use of four line wires throughout the section to be protected. The light signals are similar to those used for automatically signalling a normal single line section.

If the section A-B is occupied, one of the red lights prohibiting entrance to it at C is alight; the relative position of the red light shows if the section is occupied by an A-B train, or one going from B to A.

Signalling based on this principle permits of carrying out all possible movements, wheter entering or leaving at A, B or C, that is at no matter what extreme point of the single line layout.

Should an attempt be made to take possession of the section simultaneously at A, B and C, then the movement at C is given the preference.

The controls can be affected automatically and manually, or entirely manually.

The general operating instructions applying to the use of the « two directions » signalling apply equally in this case.

This system gives entire satisfaction and affords every guarantee of correct and safe working.

Postcript. — The reply of the North Milan Railway reached us after this report had been completed. The particulars given on the subject of the various systems of signalling in use on that line not being sufficiently detailed, we have been obliged to limit ourselves to completing Tables I, II and III.

TA

Country	NAME OF COMPANY	Route mileage (km)	Single track mileage (km)	Length in km of each sing track line		
				Maximum	Average	Minin
AUSTRIA	*Austrian Federal Railways*	6 036	3 925 16 491	218	35	2
BELGIUM AND COLONY	*Société Nationale des Chemins de fer belges* .	5 025	2 265	55	30	7
	Société Nationale des Chemins de fer vicinaux .	4 000	3 000	50	20	5
	Office d'exploitation des Transports coloniaux.	396 (*)	396	—	—	—
FINLAND	*State Railways*	6 795	4 556	269	—	—
FRANCE	*Société Générale des Chemins de fer économiques*	2 200 including leased lines, or (*a*) + (*b*)	2 200	—	—	—
	a = « *Réseau de la Gironde* »	327	327	49	28	12
	b = « *Réseau breton* »	424	424	72	44	10
ALGERIA AND TUNISIA	*Algerian Railways*	2 200 2 100	2 000 2 100	732 —	— —	12 —
	Gafsa Railways	455	455	240	—	13
	Tunisian Railways	1 658	1 641	290	87	4
AFRICA	*Franco-Ethiopian Railway from Djibuti to Addis-Ababa*	780	780	—	—	—
	Madagascar Railways	855	855	20	10	1.70
	Réunion Railways	127	127	—	—	—

Note : (*) Mayumbé-Kivu line not included.

ge in mm	Types of rail used and weight in kg per meter Flat bottom = V Grooved rail = G Stepped rail = O Bull-headed rail — D. C.	Distance in metres between loops or sidings on single lines			Useful length of loop or siding track (in metres)		
		Maximum	Average	Minimum	Maximum	Average	Minimum
1 435 1 000 760	V : 45 V : 26 V : 26	12 000	5 500	1 500	700 250 250	400 150 150	250 100 100
1 435	V : 40 and 50	25 000	6 500	2 000	700	500	300
1 000	V : 32 ; G : { 49 / 51	5 500	2 000	150	260	80	20
1 067	33.4	13 500	9 800	4 100	534	400	300
1 524	22, 343 28-38 (mixed) 25 30 33.480 43.567	20 000	8 500	1 700	—	—	42
—	—	—	—	—	—	—	—
1 440 1 000	V : 25 to 30 V : 25 D. C. : 25	12 000 11 000	6 000 5 000	3 000 2 000	300 330	260 250	235 220
1 450 and 1 000	46, 50 and 55 25, 28 and 36	36 000 —	— —	1 400 —	660 300	500 250	250 110
1 000	25	43 500	14 600	3 300	440	400	155
1 437 1 000	25, 30, 36, 38, 46, 49.6 and 50 20, 25, 30, 34 and 36	40 300	12 000	4 500	628	350	207
1 000	20, 25, 26 and 30	46 000	21 000	7 000	350	200	150
1 000	25, 26 and 30	20 500	10 400	1 750	400	260	108
1 000	21 and 26	17 000	10 000	6 000	192	—	62

T

Country	NAME OF COMPANY	Route mileage (km)	Single track mileage (km)	Length in km of each si track line		
				Maximum	Average	Mini
GREECE	*Greek State Railways*	1 259 of which 1 237 being worked at present	1 259	—	—	
HUNGARY	*Hungarian State Railways*	7 967	7 316	—	—	-
ITALY	*North of Milan Railway*	236	153	40	24	
LUXEMBURG	*Luxemburg Railways*	505	219 112	55 45	10 28	0. 10.
NORWAY	*State Railways*	4 392	4 333	571	108.3	
NETHERLANDS	*Netherlands Railways*	5 642	1 893	50	35	
PORTUGAL	*Portuguese Railway Company*	2 807	2 437	381	95	
		756	750	140	68	
SWITZERLAND	*Swiss Federal Railways*	2 912	1 710 74	84	29.5	
	Raethian Railway	394	394	89	49	
	Emmenthal-Burgdorf-Thun Railway . . .	169	169	77	69	
TURKEY	*Turkish State Ports and Railways*	7 736	7 675	19	9	

inued).

ge in mm	Types of rail used and weight in kg per metre Float bottom = V Grooved rail = G Stepped rail = O Bull-headed rail = D. C.	Distance in metres between loops or sidings on single lines			Useful length of loop or siding track (in metres)		
		Maximum	Average	Minimum	Maximum	Average	Minimum
1 435	various	18 500	7 000	1 500	1 000	700	414
1 435	23.6; 34.5; 42.8; 44.3 and 48.3	—	—	—	—	—	—
760	10.9; 13.75 and 18.1						
1 435	V : 30 and V : 36	9 590	4 050	1 720	450	230	100
1 435	V : 33 to 45	9 000	5 000	3 000	600	400	200
1 000	V : 23 to 26; O : 50	7 000	4 000	3 000	160	80	20
435	20; 20.5; 25; 27.88; 28.77	27 000	7 500	1 000	620	—	133
067	29.26; 30; 33.4;						
750	35; 37.5; 40; 41 and 49						
435	P. N. 38 and 46	12 000	7 000	4 000	650	600	500
665	30; 36; 39.8; 40; 45 and 46	20 100	8 500	1 500	1 400	415	183
000	20; 21.2; 24.5; 24.7; 24.8; 25; 26; 30; 34 and 36	12 340	5 100	1 200	453	280	109
435	C. F. F. I. 46	10 980	3 800	900	930	385	61
000	C. F. F. V. 36 C. F. F. II 48 (in tunnels)						
000	24.3; 25; 27 et 30.1	6 623	3 000	800	342	160	58
435	S. B. B. V.	—	—	—	546	140	50
524 / 435 / 750	Various types of flat bottomed rail	20 000	10 000	2 500	1 850	500	400

T

Country	NAME OF ADMINISTRATION	Frequency of traffic on single lines — Number of train movements *in each direction* per hour per day or per week.	Speed in km per hour on single lines			
			Average (including stops)		Maximum	
			Goods	Passeng.	Goods	Pass
AUSTRIA	*Austrian Federal Railways. . .*	2 in 3 hours.	45	75	60	10
BELGIUM AND COLONY	*Société Nationale des Chemins de fer belges . . . .*	Variable from 1 to 3 per hour to 4 to 20 per day.	—	20 to 55	—	9
	Société Nationale des Chemins de fer vicinaux	1° With traction, other than electric, average of 1 every 2 hours. 2° With electric traction an average of 3 per hour, with maximum of 20.	—	16 to 30	—	7
	Office d'Exploitation des Transports coloniaux	8 per day.	16 to 25	34	—	—
FINLAND	*State Railways . . . .*	2 to 3 per hour maximum.	—	25 to 45	—	11
FRANCE	*Société Générale des Chemins de fer économiques.*					
	«Réseau de la Gironde». . . .	10 per day to 14 per week.	—	45	—	6
	«Réseau breton»	6 per day to 21 per week.	—	45	—	7
ALGERIA AND TUNISIA	*Algerian Railways . . . . . .*	7 to 19 per day.	—	49 to 65	—	12
	Gafsa Railways	1 to 9 per day.	20	24 to 60	45	50 t
	Tunisian Railways	1 in 2 hours.	20	40 to 60	45 to 55	70 t
AFRICA	*Franco-Ethiopian Railway from Djibuti to Addis-Ababa. . . .*	3 per day.	30	40 to 50	45	55 t
	Madagascar Railways	10 per day.	20	32	45	4
	Reunion Railways	1, 2 or 3 per hour.	20 to 30	25	60	

II.

Composition of trains running on single lines. Weight given in metric tonnes								Length of train given as per number of axles (E) in metres (m) or number of vehicles (V)			
Normal				Special				Normal		Special	
Goods		Passenger		Goods		Passenger		Goods	Passenger	Goods	Passeng.
Motor coach or total	Trailer	Motor coach or total	Trailer	Motor coach or total	Trailer	Motor coach or total	Trailer				
50 to 120	220 to 420	50 to 75	90 to 260	50 to 150	480 to 720	50 to 150	360 to 600	36 to 70E.	12 to 26 E	60 to 120E	60 E
Variable.				Variable.				Variable.			
Variable.		10 to 22	5.6 to 16.8	Variable.		22	30	—	28 m (2 V)	—	50 m (4 V)
80	550	—	—	80	550	—	—	200 m		400 m	
—	200	—	—	—	1 300	—	—	—		550 m	
Variable.				17 to 400		—		—		—	
Variable.				17 to 270		—		—		—	
—		150 to 496		—		230 to 576		—	75 to 226 m	—	
460 to 810		440 to 650		440 to 610				377 m		395 m	
300 to 800		190 to 280		—		—		—	—	60 V	24 V
motor coach + trailers = 60 + 140				—				160 m		—	
Variable.				600				Variable.		350 m	
12 to 15	28 to 43	12 to 15	50 to 182	18	172	18	312	101 m		157.86 m	155.31 m

TABLE

Country	NAME OF ADMINISTRATION	Frequency of traffic on single lines — Number of train movements *in each direction* per hour per day or per week	Speed in km per hour on single lines: Average (including stops)		Maximum	
			Goods	Passeng.	Goods	Passeng.
GREECE	*Greek State Railways*	3 per hour.	26		72	
HUNGARY	*Hungarian State Railways* . . .	—	—		—	
ITALY	*North of Milan Railway*	from 2 to 8 per hour to 12 to 85 per day.	25 to 55		—	60
LUXEMBURG	*Luxemburg Railways*	2 to 22 per day.	13 to 30	20 to 50	15 to 50	35 to 80
NORWAY	*State Railways*	7 to 8 per day.	35 to 50	70 to 90	60	100
NETHERLANDS	*Netherlands Railways*	maximum of 8 passenger trains and 17 goods trains daily.	—	48 to 56	—	95
PORTUGAL	*Portuguese Railway Company* .					
	1 665 *mm gauge*	3 in 2 hours.	25 to 36	58.2	45 to 67	90
	1 000 *mm gauge*	2 per hour.	12	45	36	72
SWITZERLAND	*Swiss Federal Railways*	39 per day.	36	37 to 64	—	125
	Raethian Railway	7 to 35 per day.	—	20 to 41	—	65
	Emmenthal - Burgdorf - Thun Railway	2 to 5 per hour.	—	38	—	80
TURKEY	*Turkish State Ports and Railways.*	1 per hour.	—	47	—	80

I *(continued)*.

Composition of trains running on single lines. Weight given in metric tonnes.								Length of train given as per number of axles (E) in metres (m) or number of vehicles (V)			
Normal				Special							
Goods		Passenger		Goods		Passenger		Normal		Special	
Motor coach or total	Trailer	Motor coach or total	Trailer	Motor coach or total	Trailer	Motor coach or total	Trailer	Goods	Passeng.	Goods	Passeng.
76 to 105	300 to 600	81 to 98	220 to 250	76 to 105	1 000	81 to 98	450	—	250 m	500 m	300 m
—				—				—		—	
Variable.				Variable.		60	200	variable : from 20 to 200 m			
Variable.				Variable.				30 to 520	16 to 130	40 to 570 m	30 to 170 m
Variable.				Variable.				290 m	—	520 m	—
1 000 to 1 200		250		—				55 V	7 V	60 V	15 V
104 50	309 75	114 50	242 102	104 50	489 125	140 50	390 183	350 m 103 m	180 m 85 m	500 m 163 m	300 m 148 m
500		210 to 360		1 345		570 to 810		258 m	103to163m	768 m	378to396m
16 to 66				32 to 175				32 to 90		58 to 200 m	
80 to 130				440 to 500				43 to 70 m		360 m	
—				—				60 to 70 E		90 to 120 E	

TABLE

Country	NAME OF ADMINISTRATION	Method of traction used on single lines				
		Steam	Electric	Petrol	Fuel oil	Diesel electric D. E.
AUSTRIA	*Austrian Federal Railways*	Steam	Electric	—	Fuel oil	—
BELGIUM AND COLONY	*Société Nationale des Chemins de fer belges*	Steam	—	—	Fuel oil	—
	Société Nationale des Chemins de fer vicinaux	Steam	Electric	—	Fuel oil	—
	Office d'Exploitation des Transports coloniaux	Steam	—	—	—	D. E. (*)
FINLAND	*State Railways*	Steam	—	—	Fuel oil	
FRANCE	*Société Générale des Chemins de fer économiques.*	Steam	—	—	Fuel oil	D. E.
	« *Réseau de la Gironde* »					
	« *Réseau breton* »					
ALGERIA AND TUNISIA	*Algerian Railways*	Steam	Electric	Petrol	Fuel oil	—
	Gafsa Railways	Steam	—	—	Fuel oil	—
	Tunisian Railways	Steam	—	—	Fuel oil	—
AFRICA	*Franco-Ethiopian Railway from Djibuti to Addis-Ababa*	Steam	—	—	Fuel oil	D. E. (*)
	Madagascar Railways	Steam	—	Petrol	—	D. E.
	Reunion Railways	Steam	—	Petrol	Fuel oil	—

Note : (*) Some Diesel-Electric locomotives will shortly be put into service.

(*) D. E. = Diesel-Electric

continued).

Type of signalling in service on single lines							Form of signalling now under consideration	Is there any connection between the type of signalling used and the method of traction.
Train staff		Telephone			Automat. electric	Special		
dinary	electric	Traffic controller	Block by messages only	With block apparatus				
—	—	—	—	+	—	—	—	Yes.
—	—	+	—	+	—	—	Mechanical (block system).	No.
—	—	—	—	—	+	—	Automatic electric.	Yes.
—	+	—	—	—	—	—	—	—
—	—	—	+	+	—	—	Automatic signalling controlled by track circuits and using colour-light signals.	No.
							None.	No.
—	—	—	+	—	—	+	—	—
—	—	—	+	—	—	+	—	—
+	—	+	+	—	—	+	—	No.
—	—	+	—	—	—	+	—	—
—	—	—	+	—	—	+	—	No.
—	—	—	+	—	—	—	—	—
—	—	—	+	—	—	—	Block working with the aid of disc type signals and electric locking.	No.
—	—	—	—	—	—	+	None.	None.

TA

Country	NAME OF ADMINISTRATION	Method of traction used on single lines				
		Steam	Electric	Petrol	Fuel oil	Diese electr D.E.
GREECE	*Greek State Railways . . . .*	Steam	—	—	—	—
HUNGARY	*Hungarian State Railways . . .*	Steam	—	—	Fuel oil	—
ITALY	*North of Milan Railway . . .*	Steam	Electric	—	Fuel oil	—
LUXEMBURG	*Luxemburg Railways . . . . .*	Steam	—	—	Fuel oil	—
NORWAY	*State Railways . . . .*	Steam	Electric	—	—	—
NETHERLANDS	*Netherlands Railways . . . . .*	Steam	Electric	—	Fuel oil	—
PORTUGAL	*Portuguese Railway Company .* *1 665 mm gauge . . . . . .* *1 000 mm gauge . . . . . .*	Steam	—	Petrol	Fuel oil	D.E
SWITZERLAND	*Swiss Federal Railways . . . .*	Steam	Electric	Petrol	Fuel oil	—
	Raethian Railway	—	Electric	—	—	—
	Emmenthal - Burgdorf - Thun Railway	—	Electric	—	—	—
TURKEY	*Turkish State Ports and Railways.*	Steam	—	Petrol	Fuel oil	—

II *(continued)*.

Type of signalling in service on single lines							Form of signalling now under consideration.	Is there any connection between the type of signalling used and the method of traction?
Train staff		Telephone			Automatic electric	Special		
ordinary	electric	Traffic controller	Block by messages only	With block apparatus				
—	—	—	—	+	—	—	Mechanical (block-system).	No.
—	—	—	+	+	—	—	Mechanical (block-system).	No.
—	—	+	+	+	—	—	Signalling system being designed.	No.
—	—	—	—	+	—	—	Mechanical apparatus, with lever or crank handle type locking frames, semaphore signals, with bolting of facing points.	No.
—	—	—	+	+	—	—	Colour-light signals at the crossing stations in conjunction with manual block apparatus.	Yes.
+	—	—	—	+	—	—	Automatic colour-light signalling on electrified lines.	Yes.
—	—	—	+	—	—	—	A scheme for new signalling to be used on all lines is being designed.	No.
—	—	—	—	+	—	—	Light signals are systematically being substituted for the mechanical signals.	No.
—	—	—	—	+	—	—	—	—
—	—	—	—	+	—	—	Electric colour-light signalling.	No.
—	—	—	+	—	—	—	The adoption of colour-light signalling on dense traffic sections is being considered.	Yes.

Country	NAME OF COMPANY	I Reason for not installing signalling generally	II Cost of installation	III Cost of maintenance	IV More than one train normally allowed in section
AUSTRIA	*Austrian Federal Railways* . . .	Light traffic.	—	—	—
BELGIUM AND COLONY	*Société Nationale des Chemins de fer belges*	To keep working expenses to a minimum	—	—	Yes if there is an intermediate block post.
	Société Nationale des Chemins de fer vicinaux	Light traffic and to reduce working expenses.	50 000 B. frs. including wiring and cables.	2 500 B. frs.	No.
	Office d'Exploitation des Transports coloniaux	—	—	—	No.
FINLAND	*State Railways*	Inability to obtain the equipment	—	—	Yes, if there is an intermediate block post.
FRANCE	*Société Générale des Chemins de fer économiques*	Not justified with such light average traffic.	—	—	No.
ALGERIA AND TUNISIA	*Algerian Railways*	For economic reasons.	from 1 500 000 to 5 000 000 Fr. fr. according to type.	—	No.
	Gafsa Railways	Frequency of traffic does not call for signalling.	—	—	—
	Tunisian Railways	Traffic too light.	—	—	No.
AFRICA	*Franco-Ethiopian Railway from Djibuti to Addis-Ababa*	Traffic too light.	—	—	No.
	Madagascar Railways	—	—	—	No.
	Reunion Railways	—	—	—	Yes, at 10 to 15 minute intervals.

II.

V More than one train in section under exceptional conditions	VI Returning to starting point normally allowed.	VII Returning to starting point allowed under exceptional conditions.	VIII Signalling found satisfactory.	IX Voltage limits	X Repeating lights	XI Automatic working	XII Manual and automatic control	XIII « Three direction » working
Yes.	Yes, if provided for in the working time-table.	Yes, with station-master's permission.	Yes.	150 V at night and 220 V by day. (alt current).	No.	Automatic or manual according to circumstances.	Yes.	No.
—	Yes. (Engineers work trains and local movements.)	—	Yes.	—	—	—	—	—
Yes.	No.	Yes.	Yes.	450 to 750 V. (direct current).	Yes.	Yes.	Yes.	Yes.
No.	No.	No.	Yes.	—	—	No.	—	Yes (one.)
—	No.	Yes.	Not entirely seeing the impossibility of completing the installations.	—	—	—	—	—
Yes.	No.	Yes.	The ordinary rules suffice to cover.	—	—	—	—	—
Yes. if telephone block is used.	No.	Yes.	Present signalling meets traffic requirements.	—	—	—	—	—
—	—	—	—	—	—	-	—	—
No.	No.	No.	No, modifications under consideration.	—	—	—	—	—
Yes, in case of breakdown.	No.	Yes, under special order.	—	—	—	—	—	—
Yes, in case of delay or breakdown	Yes. only under a special regulation.	Yes.	No, the signalling of the stations has yet to be completed.	—	—	—	—	—
Yes.	Yes. in case of breakdown or a ballast train working on line.	Yes.	—	—	—	—	—	—

TABL[E]

Country	NAME OF COMPANY	I Reason for not installing signalling generally	II Cost of installation	III Cost of maintenance	IV More than one train normally allowed in section
GREECE	*Greek State Railways*	Light traffic.	5 000 dollars	200 dollars	No.
HUNGARY	*Hungarian State Railways* . . .	Light traffic.	—	—	Yes, in clearly specified conditions.
ITALY	*North of Milan Railway*. . . .	—	Variable.	50 000 lire.	No.
LUXEMBURG	*Luxemburg Railways*	Light traffic, low speeds and need of reducing working expenses.	700 000 fr.	6 000 fr.	No.
NORWAY	*State Railways*	—	110 000 Nrw. krnr.	1 500 Nrw. krnr.	No.
NETHERLANDS	*Netherlands Railways*	For economic reasons.	40 000 fl.	180 fl.	Yes. If there is an intermediate block post.
PORTUGAL	*Portuguese Railway Company* .	For economic reasons.	—	—	No.
SWITZERLAND	*Swiss Federal Railways*	All single track sections are protected by signalling.	50 000 Sw. frs. without wiring and cables.	—	Yes. If there is an intermediate block post.
	Rhaetian Railway	—	—	—	—
	Emmenthal - Burgdorf - Thun Railway	—	18 000 Sw. frs.	—	No.
TURKEY	*Turkish State Ports and Railways.*	Light traffic, cost of installation.	block apparatus not yet installed cost would be some 17 700 doll.	maintenance cost would be some 750 doll.	Yes. Station to station working.

(continued).

V re than one n in section er exceptional onditions	VI Returning to starting point normally allowed.	VII Returning to starting point allowed under exceptional conditions.	VIII Signalling found satisfactory.	IX Voltage limits	X Repeating lights	XI Automatic working	XII Manual and automatic control	XIII « Three direction » working
s, at more than) minutes terval and slow speed.	No.	Yes, in special cases.	Yes.	—	—	—	—	—
Yes, n clearly specified onditions.	No.	Yes, in special cases.	Yes, modernisation in course of being effected.	—	—	—	—	—
No.	No.	Yes.	No.	—	—	—	—	—
s, in case accident.	No.	Yes.	Yes.	—	—	—	—	—
s, in case accident.	No.	Yes.	Yes.	220 V. c. a. ± 10 %.	Yes.	No.	Yes.	Yes.
s, in case accident.	No.	Yes.	Yes.	110 Volts ± 10 %	No.	Yes. except in the stations.	No.	Yes.
No.	No.	Yes, under special order.	—	—	—	—	—	—
—	No.	Yes, in case of breakdown or failure.	Yes.	220 V. c. a. ± 20 %.	No.	No.	—	No.
—	—	—	—	—	—	—	—	—
Yes.	No.	Yes.	Yes.	Supply voltage ± 20 %.	Yes.	Normally : no. 1 section : yes.	No.	Yes (one).
—	Yes.	—	Yes (at present).	—	—	—	—	—

[621 .337]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

15th. SESSION (ROME, 1950).

QUESTION VI :

Comparative study of the different types of transmission between motors and axles of electric locomotives, electric motor coaches and Diesel-electric railcars. — Effect on the track of the types of bogies and systems of motor suspension.

REPORT

(Bulgaria, Czechoslovakia, Finland, Greece, Hungary, Italy, Portugal and Colonies, Rumania, Turkey and Yugoslavia),

by M. J. Tapia,

Ingénieur en Chef au Service de la Traction Électrique du Réseau National des Chemins de fer espagnols, Madrid.

FOREWORD.

First of all we wish to express our appreciation at having been appointed as Reporter for Question VI for the above mentioned countries. Among the Administrations of these countries, the following ones replied to the Questionnaire sent by the Secretariat of the Congress :

Italian State Railways.
North of Milan Railway.
Portuguese Railways Company.
Mozambique Ports, Railways and Transports.
Finnish State Railways.
Czechoslovakian Railways.
Greek State Railways.
Catalan Railway Company.

We thank all the above for their replies, which in the case of the Italian State Railways and North of Milan Railways corresponded to the questionnaire sent them and in the case of the Portuguese and Catalan Railways were merely of a general nature, since they only have very few electric or diesel-electric vehicles in service.

The other Administrations mentioned above were unable to reply to the questionnaire as they have no such vehicles in service, or for other reasons.

We think it advisable to point out that in drawing up our report we have tried to avoid repetition of information already given in various publications, except in certain cases where it is necessary to make the present study clearer.

We also considered it advisable to report, when possible, in a very concrete manner, in table form, the information supplied by the different Railways, which sums up the situation at the present time; each reader can then make up his own opinions.

Proceeding in this manner, we will limit our report to an examination of the question with which we are concerned according to the replies received from the Railways;

we are sorry that these were not more numerous, so that more definite conclusions could have been arrived at.

For the sake of clearness we will divide up our Report as follows :

Chapter I : Italian and Portuguese Railways.

Chapter II : Spanish Railways.

Chapter III : A few considerations on the points covered by this report.

Summary.

Each of the first two chapters will be subdivided according to the questionnaire into :

A. General.

B. Types of individual drives.

C. Bogies.

* * *

CHAPTER I.

Portuguese and Italian Railways.

A. General.

Geographical and economic conditions in Italy have given an enormous impulse to electric traction in this country, and after what may be called a trial period during the first ten years of the current century, electrification with three phase current at 3 600 V 16.7 periods proceeded very rapidly.

In spite of the good results obtained with this system, the Italian State Railways electrified the Foggia-Benevento line in 1927 with 3 000 V direct current, taking into account the great progress already made in the technique of electrification with high tension D. C. current.

Owing to the good results of this system, D. C. electrifications proceeded at an increased rate, and at the present time the total length of electrified lines on the Italian Railways is as follows :

a) 3 000 V D. C. current : 4 019 km (2 600 miles);

b) 3 600 V three phase current : 1 583 km (983 miles).

The electric vehicles in service at the present time upon these lines can be grouped as follows:

D. C. Locomotives.

Group E. 626	414
Group E. 326	12
Group E. 428	239
Group E. 636	102
Group E. 424	121
Other types	18
Total	906

Three phase locomotives.

Group E. 550	85
Group E. 330	13
Group E. 431	37
Group E. 333	39
Group E. 432	40
Group E. 554	172
Total	386

In addition on the Italian State Railways the following D. C. rail motor coaches are in service :

Group ETR	16
Group ALe 790/880	135
Group ALe 883	30
Group ALe 840	3
and 62 under construction.	
Group E. 623 (650 V)	23
Other types	5
Total	212

and 62 under construction.

Tables I and II sum up the chief details about the electrified lines as well as the characteristics of the D. C. electric vehicles in service.

B. Types of individual drive.

On the Italian State Railways the rotary motion is transmitted to the wheels of D. C. electric vehicles by using :

1. — Nose suspended motors.
2. — Motors with spring drive.

We will deal with these two methods on general lines.

1. — *Nose suspended motors.*

This drive is shown in Fig. 1. The toothed rim made of nickel chrome steel is made in two parts and the centre, a single steel casting, is secured to the hub of one of the two driving wheels.

With this arangement part of the driving force is transmitted directly to one of the wheels of the vehicle and the other part is transmitted by the torsion of the axle.

The toothed rim can be changed easily by undoing the bolts securing it to the centre. The pinion is in nickel chrome steel.

Finally, the motor is suspended in the usual way : it is carried on one side on the axle by antifriction metal lined bronze

TABLE I. — **Italian Railways. — General.**

Name of the Railway	*Italian State Railways*			*North of Milan Railway*
1. *Gradients, curves and lengths of electrified lines*	Lines on the level	Lines of average gradient	Mountain lines	
Maximum gradient	6 %	13 %	25 %	30 %
Minimum radius	500 m	500 m	250 m	300 m
Length of electrified lines at present time		5 602 km		120 km
2. *Loads and speeds* :				
Trailing load (t)	1 400 1 000 800	850 Goods 600 Goods 700 (Passenger)	400 250 300	(Locomot. E. 600) 150 to 300 (according to the gradient) (Motor coaches E 700) 40 tot 110 (according to the gradient) (Motor coaches E 730) 50 tot 145 (According to the gradient)
Working speed.	55 to 70 km/h (according to the gradient) (Goods) 70 to 100 km/h (according to the gradient) (Passenger) 120 km/h (maximum speed) (Expresses)			50 to 70 km/h (Loc. E. 600) 55 to 80 km/h (Motor coaches E. 700) 55 to 80 km/h (Motor coaches E. 730)
3. *Gauge of the track*	1 435 mm			1 435 mm
4. *Date vehicles put into service*.	1 927 — 1 943			1 929 — 1 940

TABLE II. — Princip

Railways	(Locomotives) Ferrovie Italiane dello Stato					F. Nor Milan
1. *Builders*	Vehicles proposed by the Designing Office of the Italian State Railways (2)					O. M. a G. E. C
2 *Classification*	E.424	E.428	E.326	E.626	E.636	E.600
3. *Dimensioned diagram* . . .	Year 1	Year 2	Year 2	Year 2	Year 1	Year
4. *Arrangement of axles* . . .	Bo—Bo	2Bo+Bo2	2C2	Bo+Bo+Bo	Bo—Bo—Bo	Bo+B
5. *Date first vehicle put into service*	1943	1934	1930	1927	1940	1929
6. *Number of vehicles in service in 1949*.	111 (1)	117 (1)	12 (1)	255 (1)	65 (1)	6
7. *Total weight (kg)*.	72 400	135 000	114 000	93 000	101 000	64 000
8. *Total adhesive weight (kg)*.	72 400	76 000	60 000	93 000	101 000	64 000
9. *Total weight of the mechanical part (kg)*	44 000	80 000	71 000	45 000	57 000	41 000
10. *Weight of the electric equipment (kg)*	28 400	55 000	43 000	48 000	44 000	23 000
11. *Diameter of driving wheels (mm)*	1 250	1 880	2 050	1 250	1 250	1 250
12. *Diameter of guiding wheels (mm)*	—	1 110	1 110	—	—	—
13. *Type of axle box bearing*. .	Plain or roller bearings.		Plain bearings.			
14. *Are wheels balanced statically or dynamically?*	Balancing is unnecessary.					

(1) Number of locomotives in service with the characteristics given in the report.
(2) These vehicles where built by several firms. (For the total number of each group see « General »).

acteristics of vehicles dealt with.

(Motor coaches) Ferrovie Italiane dello Stato					Ferrovie Nord Milano	
Vehicles proposed by the Designing Office of the Italian State Railways					O. M. and T. I. B. B.	
Le. 790/880	ALe. 883	ALe. 840	ETR.	E.623	E.700	E.730
Year 3	Year 3		Year 3		Year 4	Year 4
Bo—Bo	Bo—Bo	Bo—Bo	Bo—1Ao—Ao1 —Bo (2 types)	Bo—Bo	Bo—Bo	Bo—Bo
1937	1942	1949	1936	1933	1929	1940
135	30	3	16	23	22	3
37 000	55 000	56 000	116 000 & 125 000	70 000	54 000	56 000
37 000	55 000	56 000	87 000 & 93 000	70 000	54 000	56 000
29 000	41 800	42 000	93 000 & 102 000	54 000	42 000	43 000
8 000	13 200	14 000	23 000	16 000	12 000	13 000
910	1 000	1 000	1 000	1 060	1 000	1 000
—	—	—	1 000	—	—	—
Roller bearings				Plain bearings.		
Balancing is unnecessary.						

TABLE II. — Princi

Railways	(Locomotives) Ferrovie Italiane dello Stato					F. No Milan
Classification	E.424	E.428	E.326	E.626	E.636	E.600
15. *Type of brake*	Breda compress. air	Westinghouse Automatic compressed air			Breda compress air	Westin autom
16. *Braking ratio*	0.78	0.84 and 1.30	0.87	0.66	0.86	0.85
17. *Are the carrying wheels braked?*	—	Yes	Yes	—	—	—
18. *Number of brake blocks per wheel*	2	2 on driving wheels. 1 on carrying wheels.		2	2	2
19. *Power at the motor shaft.*	1 960	3 620	2 720	2 720	2 720	1 47
20. *Power at the tread one hour rating (HP)*	1 860	3 450	2 600	2 600	2 600	1 40
21. *Continuous power at the motor main shaft (HP)*	1 710	3 240	2 420	2 420	2 420	1 26
22. *Continuous power at the tread (HP)*	1 620	3 100	2 320	2 320	2 320	1 20
23. *Axles with the maximum transfer of weight*	The first axle according to the direction of running.			Third axle	Leading axle.	Leadi axle c each bo
24. *Percentage of adhesive weight used*	76	78.5	79.5	81.5	83	70
25. *Adhesive weight per horse power at the tread, continuous rating (kg/HP)* . . .	44.7	24.5	25.8	40.1	43.5	53.3
26. *Tractive effort at the treads, one hour rating (kg)*	9 250	11 800	8 900	12 600	12 600	9 88

racteristics of vehicles dealt with *(continued)*.

(Motor coaches) Ferrovie Italiane dello Stato					*Ferrovie Nord Milano*	
Le.790/880	ALe.883	ALe.840	ETR.	E.623	E.700	E.730
estinghouse Automatic mpressed air	Breda Automatic compressed air			Westinghouse. Automatic compressed air		
0.80	0.85	1.10	1.6	0.85	0.90	0.90
—	—	—	Yes	—	—	—
2	2	2	2	2	2	2
510	990	990	1 480	1 050	800	1 110
460	890	890	1 330	950	720	1 100
366	750	750	1 120	910	610	880
330	675	675	1 010	820	560	800
Leading axle of each bogie.						
91.3	87.8	90.8	96.5 and 96.8	88	87	77
112.1	82.9	74	86.1 and 91.8	85.3	96.4	70
2 120	4 050	3 300	2 740	4 050	3 640	5 480

TABLE II. — Pri

Railways	*(Locomotives)* *Ferrovie Italiane dello Stato*					*F. N Mil*
Classification	E. 424	E. 428	E. 326	E. 626	E. 636	E. 6
27. *Tractive effort at the treads, continuous rating*	7 800	10 500	7 900	11 200	11 200	8 4
28. *Maximum tractive effort at the treads (kg)*	17 500	16 200	12 200	17 200	17 200	—
29. *Nature of the current feeding the traction motors*.	3 000 V. D					
30. *Number of traction motors*.	4	8	6	6	6	
31. *Type of traction motor* . .	Series 4 poles.	Series 4 poles, with commutating poles.				C. C C.T.
32. *Maximum voltage at the terminals of the motor per armature*	1 500 V					
33. *Different electric couplings of the traction motors*	2	3	3	3	3	
34. *Speed of the vehicle at one hour rating (km/h)*	54	78	78	55	55	
35. *Speed of the vehicle at continuous power (km/h)* . . .	57	80	80	57	57	
36. *Maximum speed laid down for the trials (km/h)*	140	140	140	95	140	
37. *Arrangement of the motors on the vehicle* (1)	*b)*	*a)*	*a)*	*c)*	*b)*	*c)*

(1) *a)* Completely suspended, secured to the main longitudinal solebars.
b) Completely suspended, secured to the bogie solebars.
c) Nose suspended.
d) Completely suspended, Bianchi type drive.

cteristics of vehicles dealt with *(continued)*.

(Motor coaches) Ferrovie Italiane dello Stato					*Ferrovie Nord Milano*	
Le 790/880	ALe.883	ALe.840	ETR.	E.623	E.700	E.730
1 330	2 750	2 260	1 880	3 250	2 450	3 690
3 550	6 150	4 750	4 200	8 050	—	—
				650 V D. C.	3 000 V D. C.	
4	4	4	6	4	4	4
Series 4 poles, with commutating poles.					G. D. 524 A	G. L. M. 522 H
				650 V	1 500 V	
2	2	2	3	2	2	2
59	60	74	132	64	75	75
67	65	79	143	68	80	80
140	140	140	200	120	100	100
d)	*e)*	*f)*	*d)* or *e)*	*c)*	*c)*	With quill

Completely suspended, Negri type drive with laminated springs ALe 883 (some vehicles are tted with the Negri drive using coiled springs).
Suspended by a link on the vertical through the centre of gravity with elastic gear.

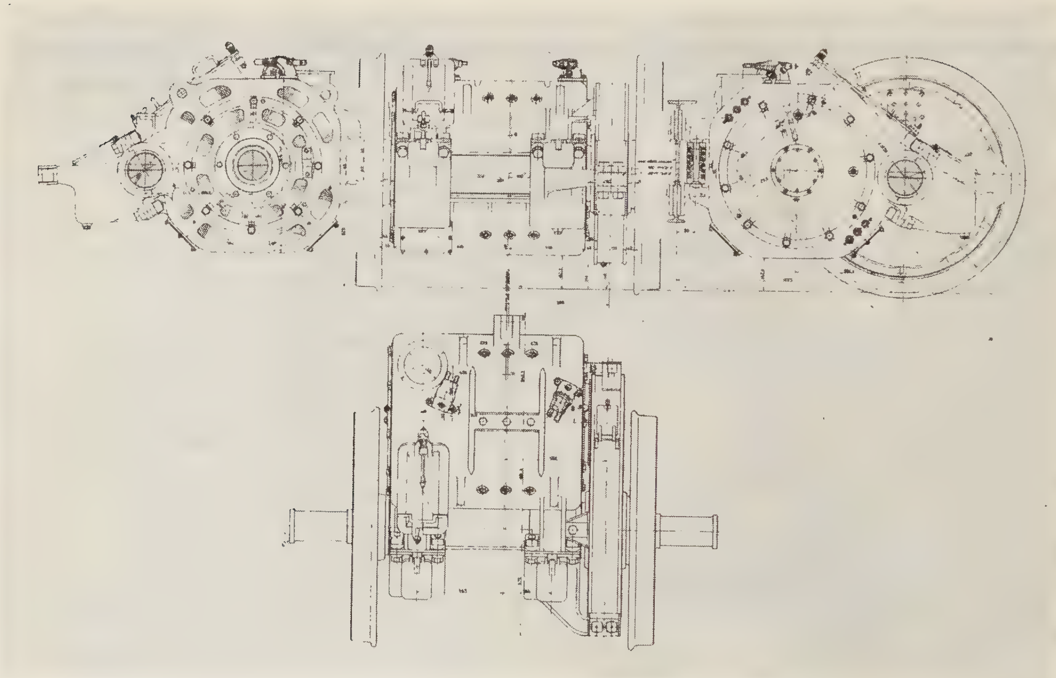


Fig. 1. — Nose suspension.

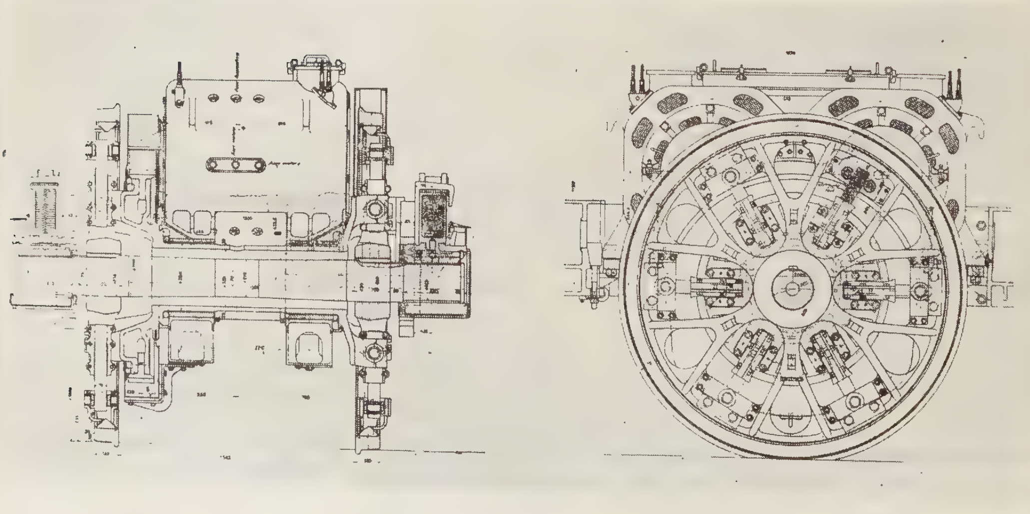


Fig. 2. — « Bianchi » drive for locomotives.

bearings, and on the other by a cross stay and two coiled springs to provide the spring support of the nose.

II. — *Motors with spring drive.*

The types of individual axle spring drives on the Italian State Railways can be grouped as follows :

a) Bianchi system;
b) Negri system with plate springs;
c) Negri system with coiled springs.

a) *Bianchi drive for locomotives.*

This drive was first used in 1930 on the first 2-Co-2 locomotive of the E. 326 group and subsequently widely for passenger train working.

This drive is shown in Fig. 2. The quill is carried on two bearings built into the carcase of the twin motors and part thereof.

The six arms located about the quill and forming part thereof maintain by bolted bearings on the axle the pins on the elliptical buckles of the springs on one side and those on one side of the quill support the toothed wheels.

In the direction of driving the nest of plates by bearing on stops of spheroidal shape drive the body of the wheel. The fact that the driving force acts near to the inside of the tyre is very favourable as regards fatigue of the springs.

These sets of springs can act at right

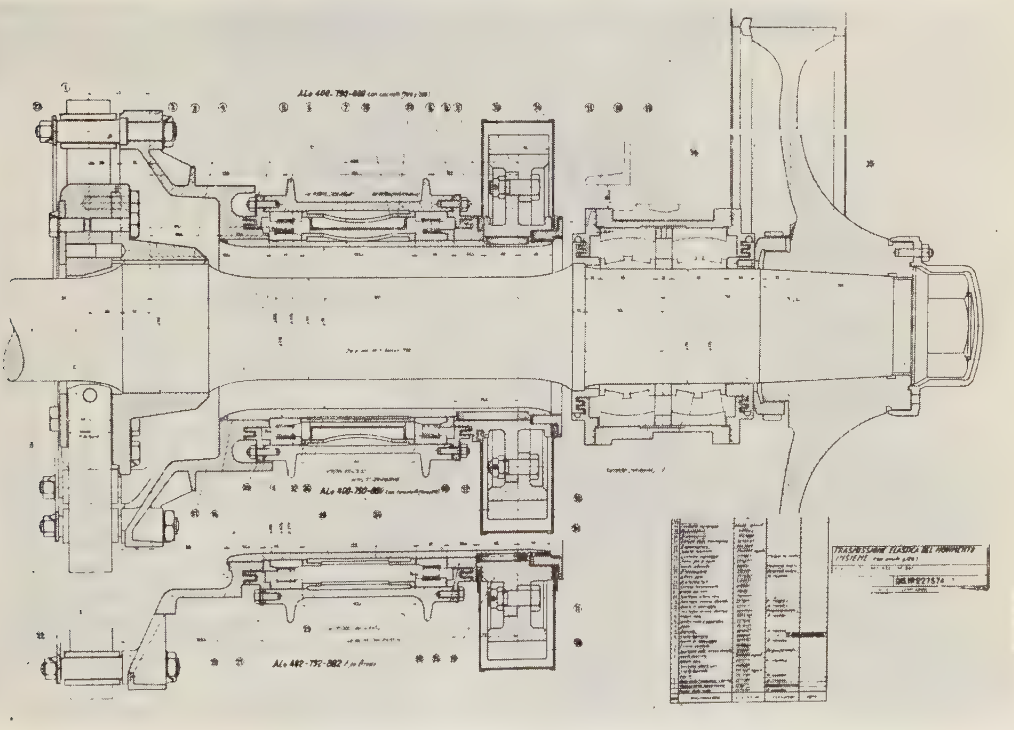


Fig. 3. — « Bianchi » drive for rail motor coaches.

angles to the drive and according to the movements of the axle.

« Bianchi » drive for electric rail motor coaches.

This type of drive (Figs. 3 and 4) is used on a large number of rail motor coaches. Each bogie has two traction bogies and the motion is transmitted from the motor to the quill by a double reduction gear and therefrom to the driving axle by means of the Bianchi spring drive.

This double transmission is required because the dimensions of the quill and the motor bearings were such that it was not possible to get the required reduction directly as the motor could not be brought any closer to the axle.

The double reduction gear in spite of some disadvantages has the benefit that the ratio can be changed. To do this the motor pinion of the intermediate gear can be changed without altering that of the quill.

b) *« Negri » type drive with laminated spring.*

This system was first used in 1936 on the E. 428, E. 636 and E. 424 groups of locomotives and on various rail motor coaches. It is shown in Fig. 5, which is the application to the E. 428 locomotives with twin motors and in Fig. 6 and 7, which give details of this drive as fitted to the E. 636 locomotives with double reduction gear.

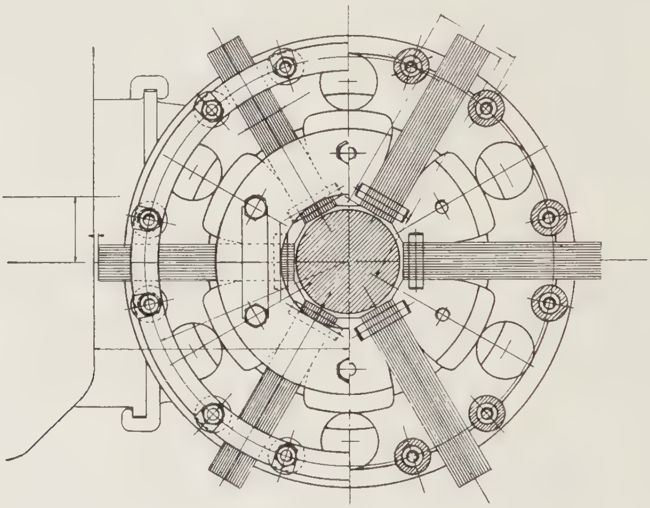


Fig. 4. — Details of the « Bianchi » drive for rail motor coaches.

This drive is very like the Bianchi drive although the springs instead of being rigidly held at their base are held at the two ends whilst these are enabled to deflect from the axis of the nest a certain angle in each direction, and are driven at their middle between their two roller bearing supports. In the Bianchi system they are driven by their free ends near the tyre.

c) *« Negri » drive with coiled springs.*

This drive is very like the one just described, the difference being that lamin-

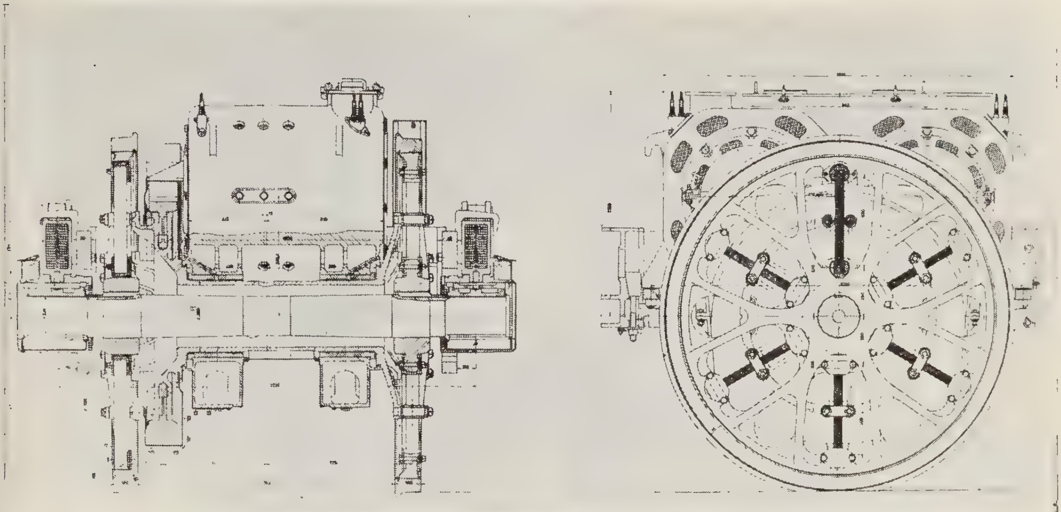


Fig. 5. — « Negri » drive with laminated springs for locomotives with twin motors.

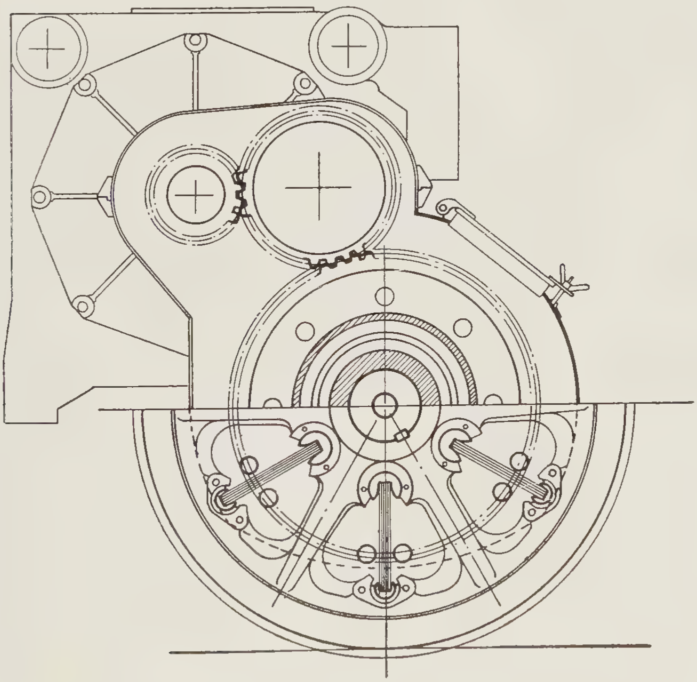


Fig. 6. — « Negri » drive with laminated springs.

ated springs have been replaced by concentric coiled springs.

As Fig. 8 illustrates these coiled springs act from the wheel boss through a pivot on two pivoting *L* levers, which bear on rollers secured to the body of the driving wheel.

It must be pointed out that although the drawbacks of this drive due to lubricating difficulties have been reduced, the system was given up by the Italian State Railways in 1945.

Suspension by rod.

Finally we must mention the new system of suspension proposed by the Italian State Railways for the motors of the ALe. 840 rail motor coaches with the motor suspended by a rod on the vertical line through the centre of gravity as shown in Fig. 9. This system is working extremely well.

We do not think we need describe these drives in more detail as particulars of them have been published frequently.

Ratio of gears on the Italian State Railway vehicles.

On these Railways the same types of locomotives are used with different gear ratios, the better to meet the service needs.

For the standard locomotives the various ratios of the table below are used. This table is also giving the corresponding speeds and tractive efforts at the treads under continuous rating:

Group	Ratio of gearing	Speed Continuous rating	Tractive effort at the tread continuous rating
E. 326	0.281	81 km/h	7 900 kg
E. 428	0.507	80 »	10 200 »
»	0.281	74.5 km/h	11 000 »
»	0.344	90 km/h	9 300 »
E. 626	0.328	57 »	11 000 »
»	0.426	73 »	8 500 »
»	0.267	47 »	13 000 »
E. 636	0.323	57 »	11 000 »
»	0.431	73 »	8 500 »

It should be noted that although possible the use of the ratios indicated for each group of locomotives is not always to be recommended both on account of the characteristics of the working and the characteristics of the locomotive. For example, it is not advisable to use the ratio 0.426 (29/68) for the E. 626 locomotives as it would enable them to reach too high speeds for the proper preservation of the track for locomotives with nose suspended motors.

The gear ratios to which the speeds and tractive efforts in table II correspond for the different vehicles are as follows:

a) locomotives: E. 424, E. 428, E. 326, E. 626, E. 636;

ratios: 16/65, 31/101, 29/103, 24/73, 21/65;

b) rail motor coaches: ALe 790/880, ALe 883, ALe 840, ETR. E. 623;

ratios: 14/43, 16/46, 26/57, 32/42, 23/61.

Tables III and IV summarise the principal characteristics of the drives examined.

Maintenance of the drive.

The repairs to the details of the individual drive are done during the periodic

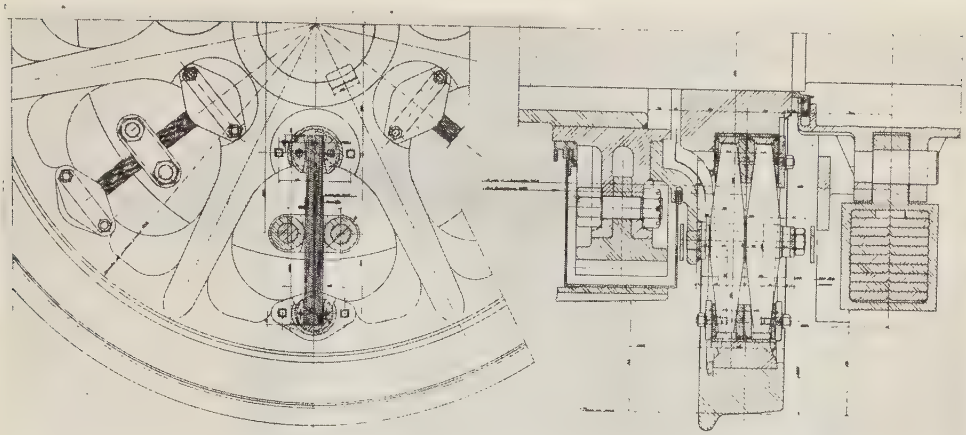


Fig. 7. — Details of the « Negri » drive with laminated springs.

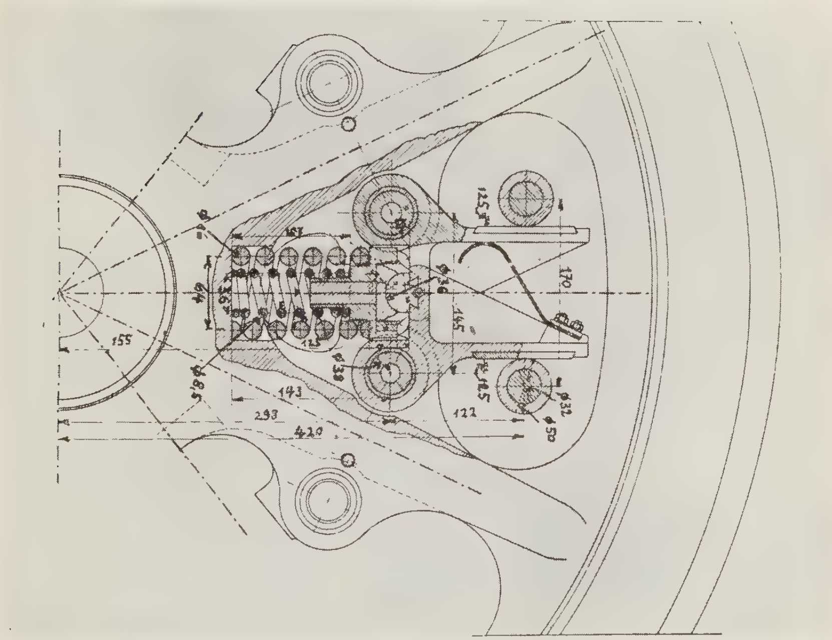


Fig. 8. — « Negri » drive with coiled springs.

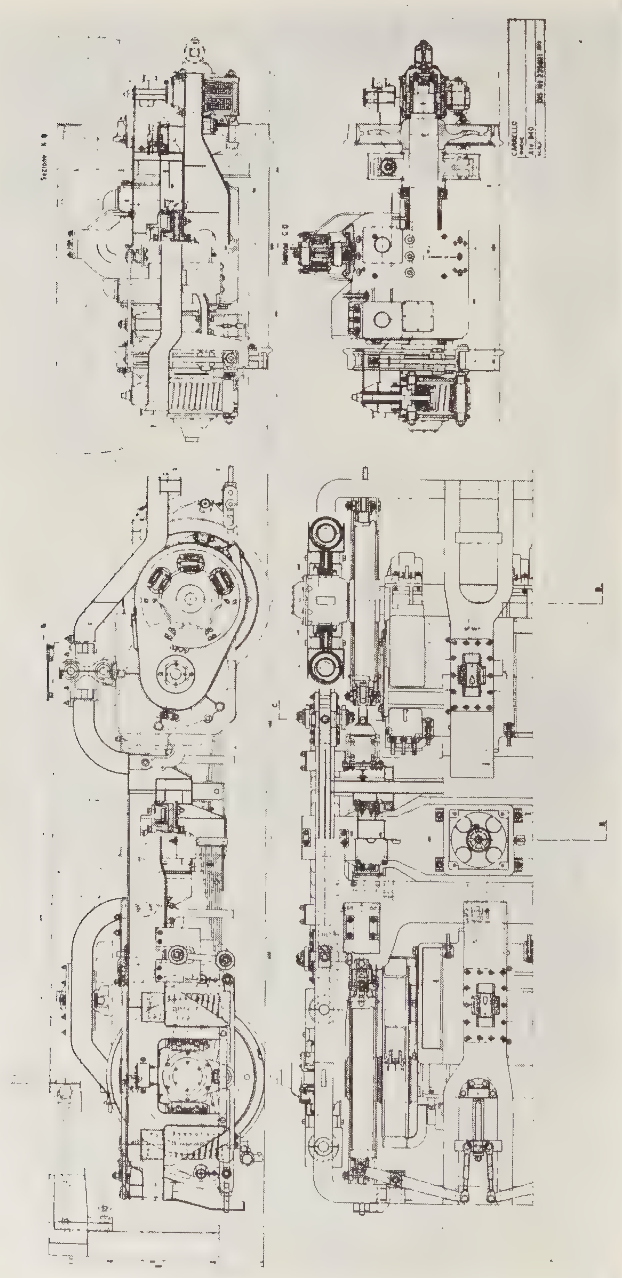


Fig. 9. — Rod suspension.

inspection specified for each type of locomotive, i.e. :

a) running inspection every 10 to 15 days (minor repairs);

b) annual inspection;

c) intermediate repairs. Every 175 000 to 200 000 km (109 000 to 125 000 miles);

d) general overhaul every 350 000 to 400 000 km (218 000 to 249 000 miles).

Complete stripping down and general repair.

Service results given by the different systems of individual axle drive.

A. *From the point of view of the Running Department :*

a) with the Bianchi and Negri types there were some breakages (not too frequent) of spring plates;

b) practically speaking there were no broken teeth in the drive of nose suspended or fully suspended motors;

c) with the Bianchi and Negri there was appreciable wear on the rubbing faces owing to the difficulty of adequate lubrication;

d) the cost of running repairs (excluding general repairs) of the Bianchi and Negri types can be taken as 10 % of the total cost of running repairs. For nose suspended motors the cost of repairs is negligible;

e) the use of the Negri drive with coiled springs was given up in 1945 owing to the cost of repairs due to the wear of certain parts. The Italian State Railways are considering constructional and technical improvements to parts showing pronounced wear. A new type of drive is also under consideration.

B. *From the point of view of the Permanent Way Department.*

The Permanent Way Department prefers the completely suspended motor as the loads on the track and bridges are lessened. Tests have not been made to ascertain the effect on the track of the different drives.

* * *

C. Bogies.

The bogies in use on the Italian State Railways locomotives and rail motor coaches are of various types but owing to lack of space we will describe only some.

a) *Bogies of the E. 626 locomotives* $(B_0+B_0+B_0)$.

The set of wheels of these locomotives (Fig. 10) is made up of 4-wheeled bogies. The frame of the middle bogie is extended over the outer bogies on which it bears through a system of levers and rods with rollers which slide on inclined planes. These inclined planes are placed on the central cross stretchers of the said inter-bogies and are arranged to work in a casing with a lubricant.

The extended solebars form part of the locomotive frame and carry the body whereas the buffing and drawgear are carried on the headstocks of the outer bogies.

The bogies are coupled together by a triangular detail with double articulation so that reciprocal movements in all directions can take place. In the vertical plane the movements are limited by a sliding link between the adjacent longitudal beams of the two bogies.

The centering device between the outer bogies and the centre bogie is obtained by means of the inclined planes mentioned above and completed by a second centering device fitted with two coiled springs with an initial load of 1 500 kg (3 307 lbs.) and a load of 3 000 kg (6 614 lbs.) when the side displacement of the bogie is 100 mm (3 15/16″).

With this arrangement the E. 626 locomotives can pass through the curves of minimum radius easily and can be allowed to run at 95 km/h. (60 miles).

TABLE III. — **Principal charact**

Railways	*Ferrovie Italia*		
1. *Type of drive*	Nose suspended	« Bianchi »	« Negri » laminated sprin
2. *Wheel arrangement with the different drives*	Bo+Bo+Bo Bo—Bo	2—Bo+Bo—2 2—Co—2 Bo—Bo Bo—1 Ao—Ao 1—Bo	Bo—Bo—Bo 2—Bo+Bo— Bo—1 Ao—Ao 1 Bo—Bo
3. *Lateral play of the axles*	Only provided to reduce to the minimum the possibility c		
4. *Drives given up*	In 1945, the Negri drive with coiled springs owing to of repairs to certain parts through wear.		
5. *Results obtained with these drives* : a) *Upkeep* . . . . b) *Cost price* . . . . c) *Behaviour*	 Easy. Low. Satisfactory up to 100 km (62 miles)/h for locomotives and 120 km (75 miles)/h for rail motor coaches.	 Rather more difficult. Dearer. Excellent at all speeds up to 200 km (124 miles)/h.	 As « Bianchi As « Bianchi As « Bianchi
6. *Weight of the drive* : a) *with train of wheels and gears (kg)* b) *without train of wheels and gears (kg)*	 580 —	 2 700 2 340	 2 050 1 700
7. *Ratio of reduction of the drive*	Very variable according to the operating demands.		
8. *Type of tooth*	Straight, for simplicity of construction and satisfactory wor		
9. *Particulars of the materials used* : a) *Toothed wheels* . . . . b) *Pinions*	 Ni—Mo steel not heat treated : R ⩾ 90 kg/mm²; A ⩾ 13 %; Cr—Ni steel oil hardened; R ⩾ 70 kg/mm²; L ⩾ 50 kg/mm²		

ividual axle drives.

llo Stato		*Ferrovie Nord Milano*	
egri » coiled springs	Rod suspension	Nose suspension	With quill and springs in the toothed wheel.
Bo—Bo	Bo—Bo	Bo+Bo Bo—Bo	Bo—Bo (Aut. E. 730).
seizing in the guides.			
		—	—
Difficult. As « Bianchi » As « Bianchi »	Easy. Low. Excellent up to 140 km(87 miles)/h. Not yet tested above 140 km/h	Satisfactory.	
1 050 600	380 —	— —	— —
		E.600 : 1/3.7 E.700 : 1/2.79	E.730 : 1/3.
		E. 600 : Straight. E. 700 : Straight.	E. 730 : Oblique.
/mm². 8 %; $\rho \geqslant 8$ kg/mm².		Hardened steel.	

TABLE IV. — **Number of vehicles and axles with the different types of individual axle drive.**

Railways	*Ferrovie dello Stato*			*Ferrovie Nord Milano*	
Type of drive	Nose suspended	«Bianchi»	«Negri»	Nose suspended	Quill and springs in toothed wheels
1. **Number of vehicles :**					
a) *Mixed traffic locomotives :*					
In 1940	448		28	6	
In 1949	414		205	6	
b) *Passenger locomotives :*					
In 1940		215	7		
In 1949		210	37		
c) *Electric rail motor coaches :*					
In 1940	32	104	66	16	3
In 1949	28	152	30	22	3
2. **Total number of axles :**					
a) *Locomotives*					
In 1940	2 688	848	196	24	—
In 1949	2 484	828	1 172	24	—
b) *Electric rail motor coaches* . .					
In 1940	128	444	264	64	12
In 1949	112	640	120	88	12
3. **Percentage of each system of drive to the total number of :**					
a) *Axles of the locomotives :*					
In 1940	72 %	22.7 %	5.3 %	100 %	—
In 1949	55.4 %	18.4 %	26.2 %	100 %	—
b) *Axles of the electric rail motor coaches :*					
In 1940	15.3 %	53.2 %	31.5 %	84.2 %	15.8 %
In 1949	12.9 %	73.3 %	13.8 %	88 %	12 %

b) *Bogies of the E. 636 locomotives* $(B_0\text{-}B_0\text{-}B_0)$.

The body on these locomotives is in two parts articulated together and the weight of each half body is distributed over the two bogies, two thirds being carried on the outer bogie and one third on the middle bogie.

Each half body is carried on the swing bolster of the the outer bogie through a central spherical bearing (Fig. 11), which allows the maximum relative freedom of movement; the bearing on the middle bogie is on two bearing plates (Fig. 12).

In this way each half body rests on three points whereby it is possible to get a predetermined static distribution of the weight both in the longitudinal and in the transverse direction. In order however to prevent the body having too great lateral oscillation side bearings are provided on the swing bolster of the outer bogies.

The traction and brake forces from the outer bogies are transmitted to the body through bolts the upper ends of which fit into an attachment on the body frame. In the case of the middle bogie these forces are transmitted through a long bolt to the articulated connection between the two half bodies in such manner that the reciprocal rotation about a vertical axis and a horizontal transverse axis can occur.

The swing bolster is carried off the solebars through two laminated springs fastened to two articulated swing links. The bolster is guided by four small links with double spherical joints which allow all the small transverse motions of the bogie but prevent any rotation relatively to the horizontal axis.

The bogie frame is carried through 8 articulated links of adjustable length on four plate springs which in turn are suspended through articulated bolts off the axle boxes.

In order to prevent heavy nosing motions adjustable hydraulic shock absorbers have ben fitted between the adjacent bogies and between the two half bodies (*D'ARBELA* system) (See *Rivista Tecnica delle Ferrovie Italiane,* April 1941). Their function is to make aperiodic any relative rotation of the parts they connect due to the coning of the types or when passing from a curve to the straight or vice versa.

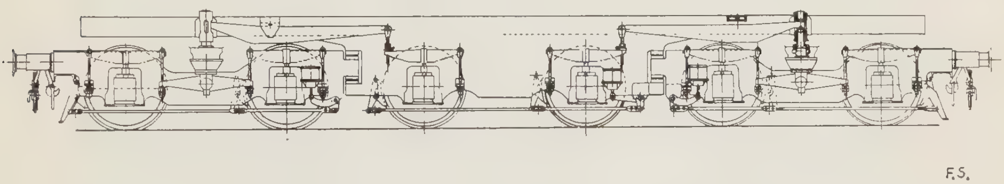


Fig. 10. — E. 626 group locomotive-bogies.

The E. 636 locomotives can pass through curves of as little as 90 m (295′ 3 3/8″) radius and ride well at 120 km/h. (75 miles). With this type of locomotive designed by the Rolling Stock Design Office, we get a locomotive of 101 t weight all available for adhesion and which makes it possible to avoid the use of bogies or leading carrying trucks.

This type of bogie is also used in the locomotives of group E. 424.

C. *Rail motor coach bogies.*

a) *Bogies used on the ALe railcars*

Each bogie has two completely spring suspended motors and the motion is transmitted from the motors to the axle through double gearing and a quill and « Bianchi » spring drive.

The roller bearing axle boxes of these

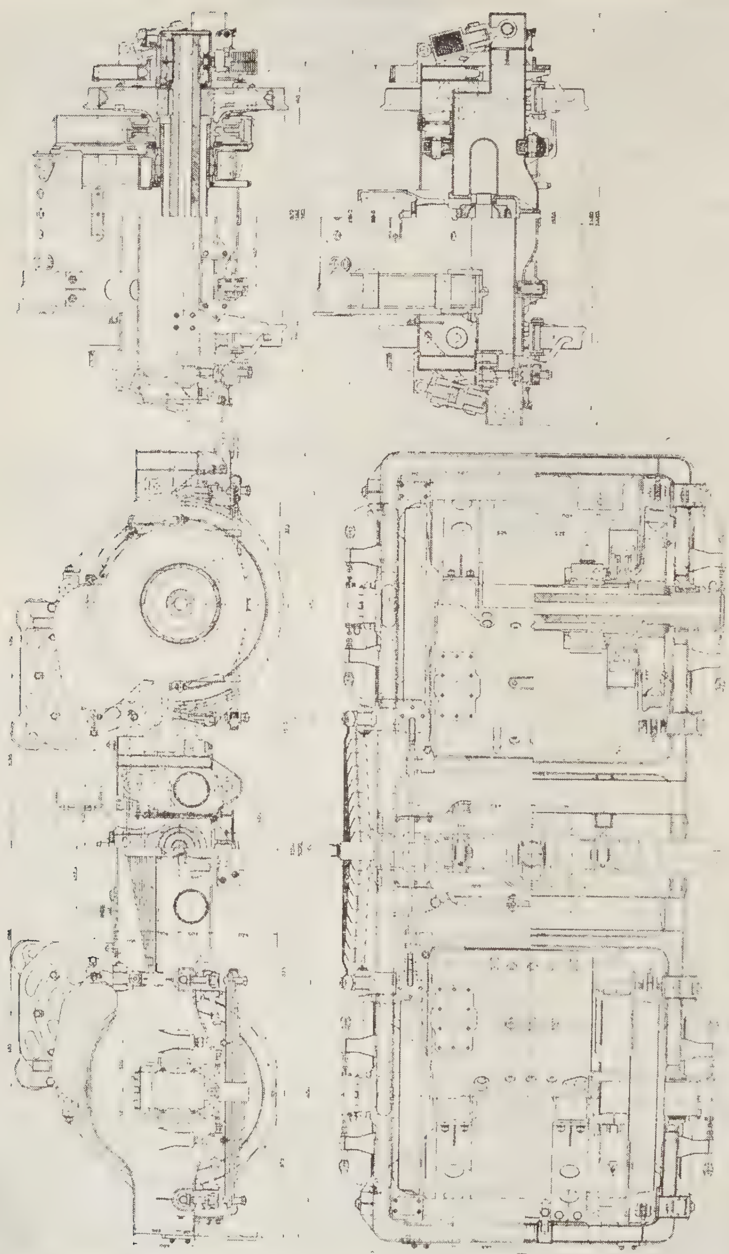


Fig. 11. — E. 636 locomotive. — End bogie.

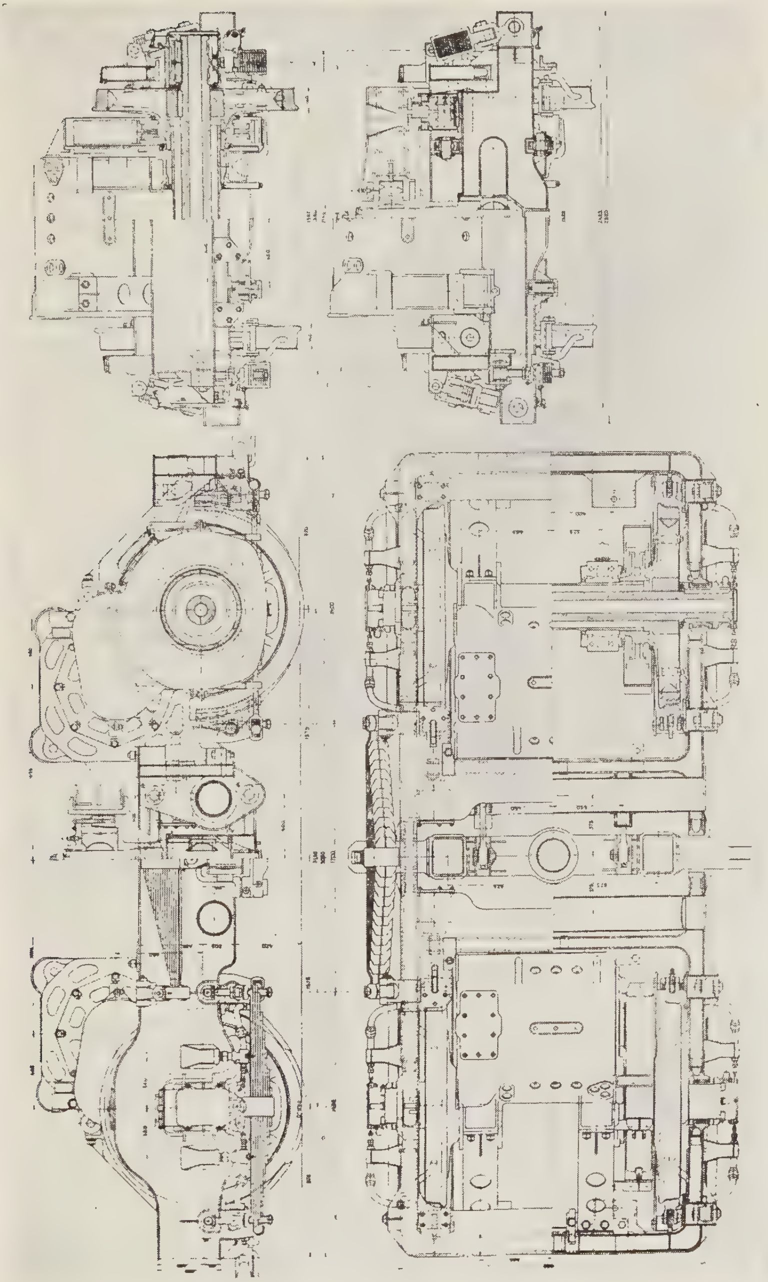


Fig. 12. — E. 636 Locomotive. — Central bogie.

bogies are fitted inside the wheels and this made it necessary to provide a demountable taper seating and to secure the wheel to the axle by bolts.

In the first series of this type of rail motor coach, the swing bolster rests on two full elliptic springs arranged transversely whereas on the bogies of the second and third series shown in Fig. 13, this suspension is obtained by means of longitudinal laminated springs carried off the sole bars by suspension links, the inclination of which has been designed to make the instantaneous centre of rotation at small oscillation come in a zone near the contact wire at normal height in order to get a good pick up of the current.

In the same way, the spring deflection constant of the springing is about 4 mm per tonne (5/32″ per tonne). This rather small figure was selected not only to avoid excessive lateral oscillation on the curves, which may be detrimental to the working of the pantagraph, but also in order that in the event of overloading of the vehicle, the excentricity between the quill and the axle would not be excessive, as this could have an unfavourable repercussion on the working of the spring drive.

The body of these vehicles is carried by the swing bolster through a centre articulation in oil; in addition, there are 2 side bearers to prevent the body taking an excessive lateral inclination relatively to the swing bolster.

b) *Bogie for high speed motor coaches. (Elettrotreni) ETR type.*

The motor rakes consist of three vehicles on 4 bogies arranged as shown in Appendix No. 3.

As shown in the corresponding figures 14 and 15, for the ETR 200 rakes, the outer bogies have one motor and the intermediate two. The transmission from the motor to the wheel is by double reduction gearing and « Bianchi » control.

The body is carried by a centre pivot on the swing bolster elastically connected to the bogie frame and by two side bearings. The whole suspension gear is designed to avoid synchronous oscillations being started at high speeds.

c) *Bogies for the ALe 840 rail motor coaches.*

On the ALe 840 rail motor coaches, a new type of bogie (Fig. 9) has been used with motors suspended by rods on the vertical line through the centre of gravity.

This bogie has given excellent results in all respects up to speeds of 140 km/h. (87 miles). So far it has not been tested at higher speeds but it is considered to be a new type of bogie of the greatest interest.

Table V gives the principal characteristics of the bogies dealt with.

Maintenance of bogies.

On the Italian State Railways maintenance of the bogies of the electric locomotives is done whilst the various inspections and overhauls already referred to are being carried out.

In the case of the rail motor coach bogies, these overhauls are divided into :

a) running overhauls : every 10 to 15 days;

b) general overhauls : every 100 000 km (62 000 miles), this including the stripping down and thorough repair of the drive.

It is to be noted that the maintenance of the electric locomotive bogies does not call for special comments, but on the contrary, as regards the maintenance of the rail motor coach bogies, many improvements have been made, consisting of :

a) replacement of certain parts which have broken in service;

b) reduction of causes of wear, especially those affecting good running.

On the North of Milan Railway the repairs to the bogies are :

a) general inspection every 125 000 km (78 000 miles) for locomotives;

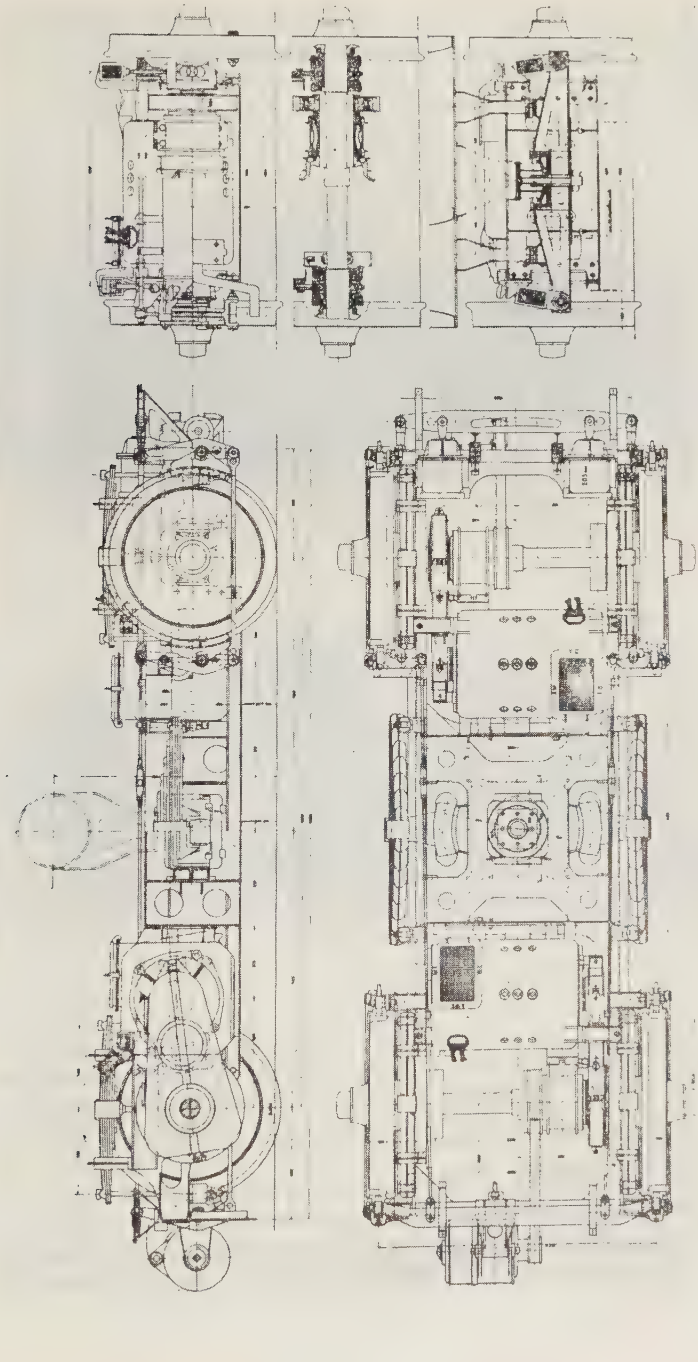


Fig. 13. – ALe 2nd and 3rd series motor coaches. – Bogie.

general inspection every 80 000 km (50 000 miles) for rail motor coaches;

b) general repair every 250 000 km (155 000 miles) for locomotives;

general repair every 160 000 km (100 000 miles) for rail motor coaches.

Effect on the condition of the track of running electric vehicles and of the diameter of the wheels.

The Permanent Way Department of the Italian State Railways considers that definite conclusions on the effect of run-

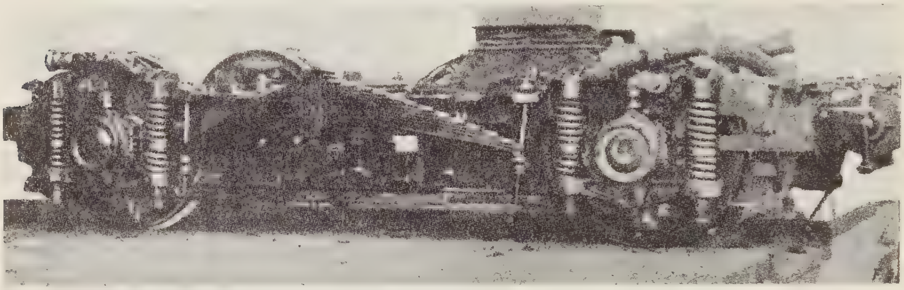


Fig. 14. — High speed ETR Motor sets. — Outer bogie.

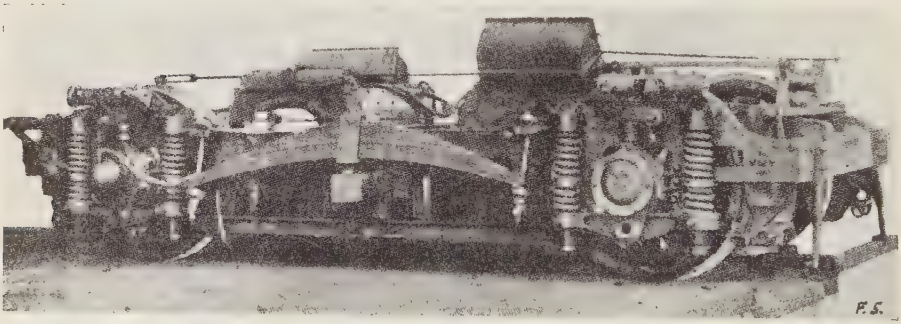


Fig. 15. — High speed ETR motor sets. — Intermediate bogie.

Stability of the vehicles when running.

At the speeds given under 5 in Table III, the stability of the vehicles is considered to be satisfactory.

Influence of axle play.

The play of the axles ought to be as small as possible, compatible with economical maintenance so as to get the greatest running stability.

ning electric stock over the track cannot be established, seeing that when a line is electrified, the trains become heavier and more frequent, and the speeds and accelerations increase considerably.

In its opinion the diameter of the wheels of the electric stock in use is such that it is not possible to think they cause appreciable loads on the rail, especially when it is appreciated that the axle loadings are

relatively low. No regulations are in force on these Railways fixing the diameter of the wheels in terms of the speed and the weight per axle.

Future tendencies as regards types of bogies.

All the bogies mentioned are in service and it is not intended to change them. Nonetheless on the Italian State Railways, there is a tendency to introduce the following constructional modifications :

a) increase the flexibility of the spring gear;

b) damp out oscillations;

c) reduce the parts subject to wear to bring down repair costs;

d) general use of swing bolsters.

Diesel electric locomotives.

The Italian State Railways possess 65 Diesel-electric locomotives taken over from the American Army; these 65 t locomotives are used for shunting. The locomotives are carried on two four wheeled bogies with 4 nose suspended motors. Each locomotive is fitted with two Buda Diesel engines : 4 strokes, 6 cylinders, 325 H. P. at 1 200 revs, each engine driving a 240 kW generator.

Portuguese Railways.

The Portuguese Railways own no electric locomotives or rail motor coaches, but have in service twelve 1 500 H. P. Diesel-electric locomotives and twelve 380 H. P. Diesel-electric tractors for shunting purposes, the principal dimensions being given in Appendix 5. The main characteristics of these locomotives and tractors are the following :

	DE. 100 & 1 100 Locomotives	*DE. 1. Tractors*
Builders	American Locomotive	General Electric
Put into service	1948	1949
Number	12	12
Dia. of wheels (mm)	1016	965
Axle boxes	Roller bearing	Plain
Brake/H.P. of engine	1 520	385 (2 motors)
No. of traction motors	4	4
Gear ratio	65/18	11/25
Type of brake	Compressed air for the locomotives and vaccum for the vehicles.	
Tractive effort at max. speed (kg)	3 200	1 500
Max. tractive effort	19 000	12 250
Total weight (kg)	109 000	44 000
Max. speed (km/h)	120	56

These vehicles have been in service for one year only, and the results are good. An excessive transversal oscillation has been noted on the locomotives and the method of correcting it is under investigation.

* * *

CHAPTER II.

Spanish Railways.

A. General.

The lines of the Spanish National Railways system as a rule run through broken country with heavy gradients. This was

TABLE V. — Pr

Railways	*Ferrovie It*		
Type of bogie	Locomotives E.626 (Bo+Bo+Bo)	Locomotives E.636 et E.424 (Bo—Bo—Bo) (Bo—Bo)	Motor coach ETR I/II (Bo—1Ao—Ao Bo)
1. *Electric coupling of the motors fitted to a bogie*	The motors of a given bogie are never cou		
2. *Number of vehicles with this type of bogie* . . *In* 1940 . . . . *In* 1949	476 619		
3. *Diameter of the wheels* (mm)	1 250	1 250	1 000
4. *Distance between axles* (mm)	2 450	3 150	3 000
5. *Anti-hunting, anti-nosing transverse coupling?*	No anti-nosing or hunting device an		
6. *Dampers*	Locomotives 636 and 424 rail motor coaches ETR ha transverse oscillations.		
7. *With or without swing bolster?*	Without.		
8. *Frame construction*	Plates.	Welded box sections.	Rolled s
9. *Optimum inclination of the swing links of the bolster*	—	15°	3° 20′
10. *Lateral support of the body on the bogies*. .	Inclined planes and rollers.		
11. *Method of carrying the body on the bogies (connexion)*	No spring gear.		By long

haracteristics of the bogies.

ello Stato			*Ferrovie Nord Milano*		
Motor coaches ALe 790/880 (Bo—Bo)	Motor coaches ALe 883 (Bo—Bo)	Motor coaches ALe 840 (Bo—Bo)	Locomotives E.600 (Bo+Bo)	Motor coaches E.700 (Bo—Bo)	Motor coaches E.730 (Bo—Bo)
permanently in series.			Series.		
202 275 (62 under construction).			6 6	16 22	3 3
910	1 000	1 000	1 250	1 000	1 000
3 000	3 000	3 100	2 800	2 700	2 700
ransverse coupling is used.					
hydraulic shock absorbers to damp out vertical, horizontal			Without shock absorbers		
With.			With.		
nd welded plates.		Welded box sections.	Rolled sections and plates.		
7°	3° 40′	0	—	—	—
olster and links.					
aminated springs.					

TABLE V. — **Principal characte**

Railways	*Ferrovie Italiane*		
Type of bogie	Locomotives E.626 (Bo+Bo+Bo)	Locomotives E.636 et E.424 (Bo—Bo—Bo) (Bo—Bo)	Motor coache ETR I/II (Bo—1Ao—A —Bo)
12. *Method of carrying the body on the bogie.*	On outside bearings at the wheelbase of the bogie.	On inside bearings at the sp	
13. *Type of axle box*	Plain bearings.	Plain bearings with rollers.	F
14. *Axles* : a) *Material used.*	*On the* « *ETR* » Cr-Ni-Mo steel : R $\geqslant$ 90 kg/r $\geqslant$ 10 kg/cm²; *t* (transversal) $\geqslant$ 8 kg/cm². *For all other vehicles* : carbon steel R $\geqslant$ 52 kg/ *e* $\geqslant$ 10 kg/cm²; *t* $\geqslant$ 8 kg/cm²;		
b) *Pressure on the pressed fit bearings (t)*.	75	75	50
c) *Broken axles*	None.		
15. *Method of suspending the frame on the wheels*	Laminated springs.		Laminated
16. *Particulars of the springs* : a) *Max. deflection (Cm)* . . . . b) *Flexibility in cm per ton*	— —	— —	32 0.6
17. *Axle box guides*	All the b		
18. *Play between the slides and axle boxes* : a) *Initial (mm)* . . . . b) *Maximum (mm)*	Play is only considered to reduce to the mini		
19. *Results obtained with these bogies* : a) *Maintenance costs*. . . . . b) *Cost price* . . . . c) *Satisfactory riding up to a speed of* :	Reduced. Low. 100 km/h.	Very low. Average. 140 km/h.	Very heavy. Average. 200 km/h.

›f the bogies *(continued)*.

dello Stato			*Ferrovie Nord Milano*		
Motor coaches ALe 790/880 (Bo—Bo)	Motor coaches ALe 883 (Bo—Bo)	Motor coaches ALe 840 (Bo—Bo)	Locomotives E.600 (Bo+Bo)	Motor coaches E.700 (Bo—Bo)	Motor coaches E.730 (Bo—Bo)
›f the wheels.					
›earings.			Plain bearings.		
‹ ⩾ 12 %; S ⩾ 70 kg/mm²; *e* (longitudinal) ‹ ⩾ 22 %; S ⩾ 36 kg/mm²;			Carbon steel.		
Coned sleeve and nuts.	50	50	—	—	—
Yes, through the the coned sleeve.	None.				
›iled springs.	Coiled springs.		Laminated and coiled springs.		
18.5 0.5	33 0.6	36 0.65	— 0.7 leaf. 1.0 helic.	— 0.75 leaf 0.76 helic.	— 1.0 leaf 0.58 helic.
›e guided by slides.					
›y possibility of the boxes seizing in the guides.			2 8		
Very heavy. Average. 140 km/h.	Heavy. Average. 140 km/h.	Reduced. Low. 140 km/h.	Reduced. —	Very low. —	Low. —
			75 km/h for locomotives-80 km/h for rail motor coaches.		

one of the chief reasons for their electrification which began, in 1911 with 6 000 V 25 periods three phase A. C. on the short 30 km (18 miles) line from Nacimiento to Gador.

In 1924 the 62 km (38 miles) long line from Ujo to Busdongo was opened with 3 000 V D. C. on an almost continuous gradient of 1 in 50 and curves of very small radius, half the line being in tunnel. Later new lines were electrified always with D. C. but at 1 500 V. At the present time the electrified system extends to 680 km (423 miles) with D. C. of which 336 km (208 miles) is double track, so that the total length of electrified track exceeds 1 000 km (620 miles).

The trains on these lines are worked by the following electric locomotives :

Series 1000	7
Series 1100	5
Series 6000	6
Series 6100	6
Series 7000	12
Series 7100	25
Series 7200	12
Series 7300	1
Series 7400	24
Series 7500	12
Total . . .	110 locomotives.

All these locomotives work at a line voltage of 1 500, except those of the 6 000 and 6 100 series at 3 000 V.

In addition for short distance passenger train services the Spanish Railways have 92 electric rail motor coaches all working on 1 500 V. These include 78 of the 300 series which are double and therefore made up of a motor coach with a trailer permanently attached (a part of the electrical equipment being installed in it), and trains of up to 8 vehicles are formed from them with single control. Table VI gives the principal dimensions of these vehicles.

Curves, gradients, speeds.

On almost all the Spanish lines there are curves of small radius down to 300 m (984 feet) and the maximum speeds on the main lines allowed in view of the said curves are the following :

For R = 300 m (984 feet) : 70 km/h. (43 m.p.h.).

For R = 400 m (1 312 feet) : 80 km/h. (50 m.p.h.).

For R $\geqslant$ 700 m (2 297 feet) : 100 km/h. (62 m.p.h.).

The ruling gradient on the electrified lines is 1 in 50 but in the Ripoll to La Tour de Carol there are sections with gradients of 1 in 25 and on the mountain line of 1 m (3′ 3 3/8″) gauge from Cercedilla to Navacerrada, the almost constant gradient is 1 in 16 2/3; the service over the line is worked by rail motor coaches.

The loads and speeds in service depend on the type of locomotive, the make up of the trains and the location of the line; for example the 7400 and 7500 series of 3 000 and 4 200 rail horse power (one hour rating) can haul over gradients of 1 in 16.

Locomotives series 7400 :

Passenger. 300 t at 60 km/h. (37 m.p.h.);
Goods . . 650 t at 45 km/h. (28 m.p.h.).

Locomotives series 7500 :

Passenger. 400 t at 75 km/h. (47 m.p.h.);
Goods . . 650 t at 60 km/h. (37 m.p.h.).

* * *

B. Type of individual drive.

The Spanish Railways use :

a) nose suspended motors;

b) motors with Brown Boveri Buchli spring drive;

c) motors with Winterthur spring drive.

a) *Nose suspended motors.*

This is the system most used; most of the locomotives and all the rail motor coaches are so equipped, including the

3 000 H. P. class 7400 $C_0 + C_0$ recently delivered with electrical equipment by the Ateliers de Sécheron of Geneva, the mechanical part being Spanish built.

These locomotives have an axle weight of 16 500 kg (36 375 lbs.), can attain a speed of 100 km/h. (62 m.p.h.), and have a starting tractive effort at the wheel tread of 2 400 kg (5 291 lbs.).

The 6 traction motors are set towards the centre of the locomotive and the nose of each motor is carried by helical springs off the cross stays of the bogies.

The gear wheel with straight teeth is keyed to the driving axle, the transmission is unilateral, and the wheel like the pinion is totally rigid.

b) *Motors with Brown Boveri Buchli spring drive.*

This drive is used on the 2-C_0+C_0-2 passenger locomotives of classes 7200 and 7500 of 3 240 and 4 200 H. P. one hour rating at the wheel tread which can reach a speed of 110 km/h. (68 m.p.h.).

As Figs 16 and 17 show, each driving axle is driven by a motor carried by the bogie frame and having two elastic pinions with straight teeth which drive the gear wheels. These wheels revolve in white metal lined bearings on the ends of a quill which is rigidly fastened to the motor and surrounds the motor axles. The two toothed wheels are coupled to the driving wheels by the Brown Boveri drive with rods. The drive is inside the driving wheels.

c) *Motors with Winterthur spring drive.*

This drive is fitted to the 2-C_0+C_0-2 locomotive No. 7301 with a power of 3 770 H. P. at one hour rating at the wheel tread, with a maximum speed of 110 km/h. (68 m.p.h.).

Each driving axle of this locomotive is driven by two twin motors and the transmission from the two motors to the axle (Fig. 18) is through double reduction gearing with helical gears in the first reduction (from the motor to the intermediate shaft) whilst in the final drive from the intermediate shaft to the motor axle straight toothed gears are used.

We will not give any further details of these well known types of drives.

Maintenance work.

The drives are inspected during the periodic inspection of the vehicle :

a) inspection of bearings : every 15 days;

b) general inspection : every 50 000 km (31 000 miles);

c) light repairs : every 100 000 km (62 000 miles);

d) general repairs : every 500 000 km (310 000 miles).

Service results of the different types of individual drive.

A. — *From the point of view of the Locomotive Running Department :*

a) the nose suspended motor gives good results in service, the cost of repairs is low and breakages of gears infrequent. We consider that for maximum speeds of about 80 km/h. (50 m.p.h.) for locomotives and 100 km/h. (62 m.p.h.) for rail motor coaches, it is a system which works well in service.

Nevertheless a greater number of defects through defective insulation have been recorded with nose suspended motors than with fully suspended ones. This leads to consideration of the harmful effects on the armatures of vibrations resulting from the nose suspension and the use of totally rigid pinions and gear wheels;

b) the Brown Boveri system has caused serious damage in service through the elastic pinion breaking : in 1949 5 % of the pinions on the locomotives broke after running 400 000 km (250 000 miles) since being put into service.

These failures appear to be due to the fact that, in practice, the pinions lose their elastic properties through defective lubrication or to their springs not acting properly.

TABLE VI. —

RENFE				
1. *Railway classification*	S. 1 000	S. 1 100	S. 6 000	S. 6 100
2. *Dimensioned diagram*	Year 6	—	Year 6	Year 6
3. *Wheel arrangement*	Bo+Bo	Bo+Bo	Co—Co	Co—Co
4. *Date first put into service*	1929	1933	1923	1924
5. *Number in service in 1949*	7	5	6	6
6. *Total weight (kg)*	74 800	67 500	79 500	75 000
7. *Total adhesive weight (kg)*	74 800	67 500	79 500	75 000
8. *Diameter of driving wheels (new) (mm)*	1 400	1 270	990	990
9. *Diameter of guiding wheels (new) (mm)*	—	—	—	—
10. *Type of axle box*	Plain	Plain	Plain	Plain
11. *Type of mechanical brake*	Vacuum		Vacuum	Vacuum and Compressed air.
12. *Type of electric brake*	Rheostat.	Recuperation.		
13. *Brake ratio*	0.80	0.80	0.80	0.80
14. *Are the guiding wheels braked?*	—	—	—	—

(1) Motor coaches (1) Trailer.

cteristics of the vehicles concerned.

tives					*Rail Motor coaches*	
S. 7 100	S. 7 200	S. 7 301	S. 7 400	S. 7 500	S. 300	S. 500
Year 7	Year 7	Year 8	Year 8	Year 8	Year 9	Year 9
-Co+Co—1	2—Co+Co—2	2Co+Co—2	Co+Co	2Co+Co—2	Bo—Bo (1) B—B (2)	Bo—Bo
1928	1928	1931	1944	1944	1928	1933
25	12	1	22	12	78	8
111 000	145 000	151 720	99 000	147 000	66 000 (1) 53 000 (2)	60 000
90 000	96 000	99 000	99 000	102 000	66 000	60 000
1 300	1 560	1 560	1 300	1560	996	1 000
1 036	860	860	—	860	996	—
Plain	Plain	Plain	Plain	Plain	Plain (1) Plain and with rollers (2)	Plain
Vacuum	Vacuum	Vacuum	Vacuum	Vacuum	Compressed air.	Vacuum
					Rheostat.	Rheostat.
	80 %	80 %	80 %	80 %	80 %	80 %
No	No	No	—	No	Yes R.	—

TABLE VI. —

RENFE				
Railway classification	S. 1 000	S. 1 100	S. 6 000	S. 6 100
15. *Number of brake blocks per wheel*	2	2	2	2
16. *Power at motor shafts at one hour rating (HP)*	1 460	1 280	1 720	1 720
17. *Power at the tread at one hour rating (HP).*	1 400	1 220	1 620	1 620
18. *Power at motor shafts at continuous rating (HP)*	1 050	1 180	1 660	1 400
19. *Power at the tread at continuous rating (HP)*	1 000	1 120	1 580	1 340
20. *Power at the tread at continuous rating per ton of total weight (HP/t)*	13.3	18.9	19.7	17.9
21. *Adhesive weight at the tread per horse power at continuous rating (kg/HP)*	74.8	60	50.3	55.1
22. *Tractive effort at the tread at one hour rating (kg)*	12 640	13 500	12 600	12 500
23. *Tractive effort at the tread at continuous rating (kg)*	8 200	12 000	12 120	9 600
24. *Nature of current feeding the traction motors (Line voltage)*	D. C. 1 650 V	D. C. 1 500 V	D. C. 3 000 V	D. C. 3 000 V
25. *Number of traction motors*	4	4	6	6
26. *Type of traction motors*	Series 4 poles with commutating poles			

acteristics of the vehicles concerned.

otives					*Rail motor coaches*	
S. 7 100	S. 7 200	S. 7 301	S. 7 400	S. 7 500	S. 300	S. 500
2	2	2	2	2	2	2
2 400	3 400	4 000	3 160	4 420	970	1070
2 280	3 240	3 770	3 000	4 200	920	1 020
1 880	2 920	3 280	2 520	3 540	580	995
1 800	2 760	3 120	2 400	3 360	560	948
16.2	19	20.5	24.2	22.9	8.7	14
50	34.7	31.7	41.2	30.2	11.3	63.4
19 500	15 600	18 700	17 100	19 200	5 320	6 400
14 040	13 000	13 800	12 450	14 200	3 320	4 680
D. C. 1 500 V.						
6	6	12	6	6	4	4
	S. 6 poles with commutating poles.		Series 4 poles with commutating poles.	S. 6 poles with commutating poles.	Series 4 poles with commutating poles.	

TABLE VI.

RENFE				
Railway classification	S. 1 000	S. 1 100	S. 6 000	S. 6 100
27. *Gear ratio*	16/75	19/88	18/72	18/61
28. *Maximum voltage at the terminals of the motors per armature*	1 650	750	1 000	1 500
29. *Different electric couplings of the traction motors*	2	2	2	3
30. *Speed of the vehicle at one hour rating (km/h)*	29.5	24.5	34.7	35.4
31. *Speed of the vehicle at continuous rating (km/h)*	32.5	25	35	38.3
32. *Maximum speed laid down for the trials (km/h)*	65	70	60	70
33. *Arrangement of the motors on the vehicle*.	*a)*	*a)*	*a)*	*a)*
34. *Builders* : a) *Mechanical part*.	C. A. F. (Beasain).	S.E.C.N. and Babcock Wilcox (Bilbao).	American Locomotive Works.	S.E.C.N. and Baldwin.
b) *Electrical part*.	C. E. D. F. (Tarbes).	General Electric Co.	General Electric Co.	Westinghouse

a) Nose suspended.
b) With Brown Boveri-Buchli drive.
c) Completely suspended with Winterthur drive.

teristics of the vehicles concerned *(cont.)*

otives					*Rail Motor coaches*	
S. 7 100	S. 7 200	S. 7 301	S. 7 400	S. 7 500	S. 300	S. 500
17/84	35/120	1/4.484	1/4.94	35/120	19/61	16/65
500	750	500	500	750	750	750
2	3	3	2	3	2	2
31.6	56	54.5	47	60	48.5	40
34.5	59.5	61	52	65	57	45
90	110	110	100	110	110	70
a)	*b)*	*c)*	*a)*	*b)*	*a)*	*a)*
ıskalduna Bilbao).	Babcock & Wilcox (Bilbao).	S. E. C. N. (Bilbao).	MACOSA (Valencia).	C. A. F. (Beasain).	S. E. C. N. and others.	S. E. C. N. and Métro-politan Vickers.
Ɔerlikon (Suisse).	Brown-Boveri.	Metrovick	Ateliers de Sécheron.	Brown-Boveri and Oerlikon.	Westinghouse.	

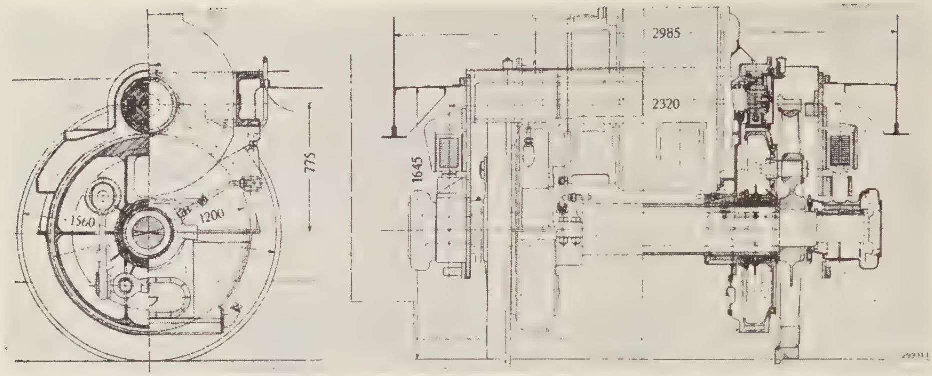


Fig. 16. — « Brown-Boveri-Buchli » type drive.

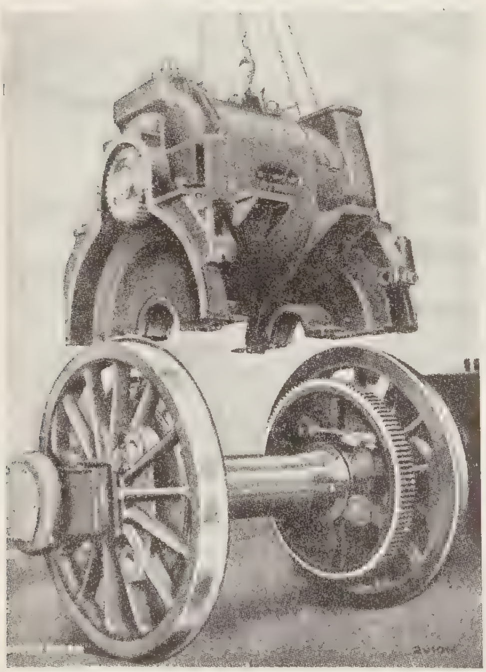


Fig. 17. — « Brown Boveri Buchli » type drive with top of the gear case.

This causes the toothed wheel to break as it is unable to withstand the intermittent stresses to which it is subjected when the centres of the quill and the driving axle do not coincide. Further in the case we are considering, the transmission is bilateral, the possibly unequal distribution of the forces as between the two pinions is very important.

The state of the track and the condition of the spring rigging also have a great influence on the proper behaviour of this type of drive which requires very delicate upkeep. At the present time the best methods for reducing these failures are being considered by the builders;

c) the Winterthur drive has given good results in service, but as there is only one locomotive so equipped, no definite conclusions can be drawn; our impression is that it is very satisfactory as regards its working and its maintenance.

B. — *From the point of view of the Permanent Way Department :*

No tests have been made to ascertain the effect on the track of the various drives used on the Spanish Railways; however, the Permanent Way Department does

prefer the elastic drive for vehicles running at high speeds.

Tables VII and VIII summarise the principal characteristics of the drives considered.

C. Bogies.

Appendix No. 10 shows the main types of bogies used by the R. E. N. F. E.; it will be seen that the type most used on goods or mixed traffic locomotives is the C_0+C_0 and for passenger locomotives the $2\text{-}C_0+C_0\text{-}2$. All the rail motor coaches and Diesel-electric locomotives have 4 wheeled bogies.

Below are given details of the more interesting types :

a) *Bogies of class 6000 locomotives* (Fig. 19).

The bogies (Fig. 20) have 32 mm (1.259 in.) thick steel plate frames connected by four cross stays, the outer being in rolled sections, the other three in cast steel, and supporting the nose of each of the three driving motors. The second from the outer end also carries the body pivot and the details to prevent excessive side movement thereof.

The body frame carried on the pivot mentioned above consists of 4 [section side frames with rolled cross members to transmit the tractive effort, the bogies not being coupled. The traction and buffing gear is carried on the headstocks of the body framing.

The suspended weight of the locomotive is carried by the axles bushes through four sets of laminated springs in each bogie. The two laminated springs, on either side, bear on the box of the center axle. As the bearing points on these springs are

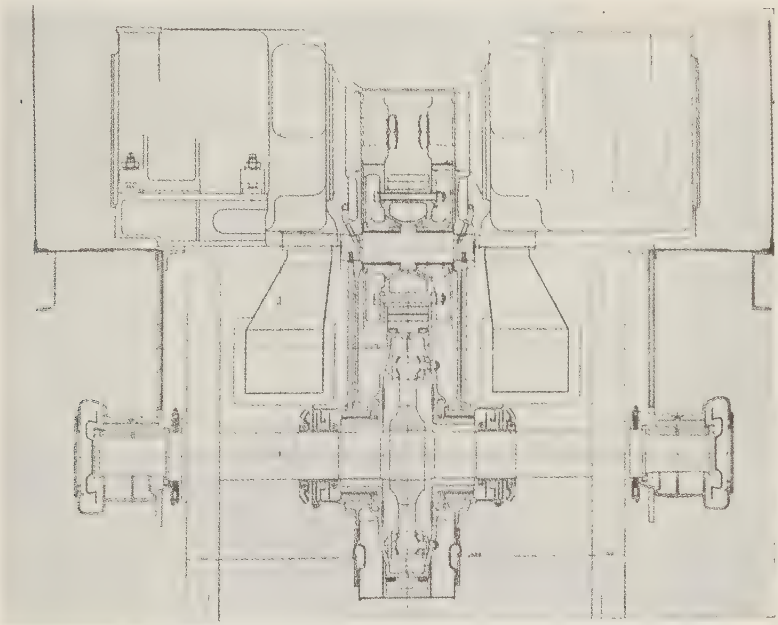


Fig. 18. — « Winterthur » drive.

TABLE VII. — **Principal characteristics of individual axle drives.**

Railway	*Red Nacional de los Ferrocarriles Españoles*		
Drive	Nose suspension	Brown Boveri-Buchli	Winterthur
Arrangement of the axles with the different types of drive . .	Bo+Bo; Co-Co; Bo-Bo; Co+Co; 1-Co+Co-1	2-Co+Co-2	2-Co+Co-2
Drives given up	None.	None.	None.
Results obtained with these drives : a) *Maintenance* . . . . b) *Cost price* . . . . . c) *Behaviour*	Eeasy. Reduced. Satisfactory up to 80 km/h for locomotives and 100 km/h for rail motor coaches.	Difficult. Dear. Satisfactory up to 110 km/h No tests carried out at higher speeds.	Easy. Dear. Satisfactory up to 110 km/h No tests carried out at higher speeds.
Total weight of the transmission.	The total weight of the toothed wheel and pinion in nose suspended motors is about 500 kg. (On some locomotives with nose suspended motors, the total unsprung weight including the axle, motor, gears and axle boxes exceeds 4 000 kg.) The total weight of the transmission in the case of completely suspended motors is of the order of 2 000 kg.		
Type of teeth.	Oblique teeth in the series 6100 locomotives and rail motor coaches; helicoidal in the case of motors with intermediate axle and Winterthur drive; and straight teeth in all other types.		
Characteristics of material used : *Pinions*. . . . . *Toothed wheels*	 Cr-Ni steel converted and hardened R $\geqslant$90 kg/mm² A $\geqslant$12 % Forged steel : R $\geqslant$70 kg/mm² A $\geqslant$15 %		

TABLE VIII. — **Number of vehicles and axles with the different types of individual axle drive.**

Railway	*Red Nacional de los Ferrocarriles Españoles*		
Type of drive	Nose suspended	Brown Boveri-Buchli	Winterthur
Number of vehicles.			
a) *Mixed traffic locomotive* :			
In 1940	61		
In 1949	83		
b) *Passenger locomotives* :			
In 1940		12	1
In 1949		24	1
c) *Electric rail motor coaches* :			
In 1940	62		
In 1949	92		
Total number of axles.			
a) *Locomotives* :			
In 1940	342	72	6
In 1949	474	144	6
b) *Electric rail motor coaches* :			
In 1940	242		
In 1949	362		
Percentage of each system of drive to the total number of :			
a) *Locomotive axles* :			
In 1940	81.5 %	17.2 %	1.3 %
In 1949	76 %	23.1 %	0.9 %
b) *Electric motor coach axles* :			
In 1940	100 %		
In 1949	100 %		

located at 1/3 the length of the spring (starting from the rear end), loading is assymetrical and thus weight can be distributed uniformly over the three axles;

b) *Bogies of classes 7000 and 7100 locomotives* (Figs. 21 and 22).

The class 7000 have two 6 wheeled bogies, the class 7100 two six wheeled bogies each with a guiding pair of wheels at the outer ends. The bogie side frames are cut out of 25 mm (0.984 inch.) plate and are connected by cross stays. The outer headstocks carry the buffing and draw gear and the inner headstocks the coupling gear between the two bogies. This gear consists of a ball joint which transmits the buffing or traction loads and

provides sufficient movement to leave the trucks free enough to be safe and to take curves properly. Owing to this form of construction the body and pivots are not subjected to any traction forces.

The body is carried firstly on each of the two trucks through a spherical pivot mounted on the stretchers between the first and second driven axles and secondly on a pad carried on a plate spring the tension of which can be adjusted and which is fastened to the inner headstocks.

The bogie frames are carried on the axle boxes through laminated springs, the springs of the two inner axle boxes being conjugated by horizontal equalisers. In the trucks of the 2-C_0+C_0-2 class 7100 locomotives the spring gear is equalised with that of the guiding axle. The motors are carried by the cross stretchers through a ball joint and coned rings.

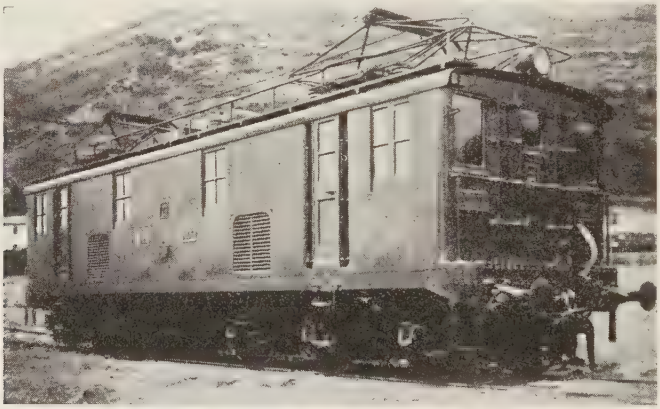


Fig. 19. — Locomotive series 6000.

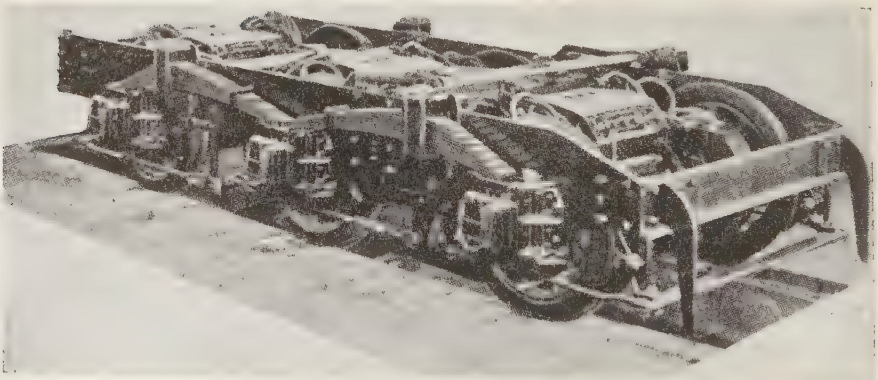


Fig. 20. — Locomotive series 6000. — Bogie.

c) *Bogies of the class 7200, 7300 and 7500 locomotives* (Figs. 23, 24).

These bogies are identical, and are shown in greater detail in Fig. 25, the bogie of class 7200 and 7500 and in Fig. 26 of locomotive No. 7301. As already pointed out the 7200 and 7500 locomotives have 6 traction motors with Brown Boveri Buchli drive, and the locomotive 7301 with the Winterthur drive two twin motors per axle.

The body is carried on two pivots 9 750 mm (384 in.) apart on the two motor bogies which are close coupled. Each pivot located between the two outer axles is fastened by its upper semi-spherical part to the body frame. The pivot rests in the pivot bearing in the steel casting forming the stretcher of the motor bogie. One of the pivot bearings has ± 25 mm (0.984 inch.) side play.

In addition at each corner of the body

Fig. 21. — Locomotive series 7000.

Fig. 22. — Locomotive series 7100.

there is an elastic support to prevent body oscillation.

Each motor bogie has three driving axles, and two carrying axles in a guiding bogie. The tyres of the middle pair of wheels have flanges 11 mm (0.433 inch.) thinner than the others to enable the locomotive to run through curves of 100 m (328 feet) without side play.

Each guiding bogie has boxed-in slides in which the semi-spherical bearings can slide transversely. A lever fastened to the motor bogie can pivot in the longitudinal sense, and has semi-spherical pads which bear on the two semi-spherical bearings.

In order to increase the friction of the boxed in slides, these have cross grooves which add to the damping and to the reduction in the side movement of the bogie. The bogie is fitted with a centering device consisting of levers, springs with high initial tension and inclined planes

Fig. 23. — Locomotive series 7200.

Fig. 24. — Locomotive series 7301.

to restore the guiding bogie to the longitudinal axis of the bogie on curves.

On each side of the pivot and of the bogie centering gear there are spherical bearers. The outer headstock of each bogie carries the standard draw and buffing gear, the inner headstock a very short coupling to transmit the traction from one bogie to the other. The two trucks in addition are connected by a bar with springs placed diagonally between the trucks, to improve the running, especially on curves.

The stretcher between the first and second axles has a spherical seat for the pivot which can move sideways ± 20 mm (0.787 inch.) in one of the bogies. The inner headstocks have the central coupling bar and a second coupling bar arranged diagonally to limit the relative displacement on curves. This headstock also carries one end of a central elastic compensator supporting the body. Lastly this headstock carries the gear for coupling the bogies in the vertical plane in order to reduce the unloading of the axles (Fig. 28).

Fig. 25. — Locomotives series 7500 and 7200. — Trucks.

c) *Bogies of the 7400 class locomotives* (Fig. 27).

These locomotives should develop a drawbar pull of 24 000 kg (52 911 lbs.) at starting with an adhesive weight of only 16.5 t per axle. To avoid as far as possible displacement of the axle loadings, it was decided to instal all the traction motors towards the centre of the locomotive.

The two bogies each three axled are coupled and the tractive force is transmitted through their frames. The 30 mm (1.181 inch.) frames of these bogies are cross stayed by three stretchers in plate and rolled sections welded together (rivetted to the frame plates), and by a strengthened stretcher between the second and third axles.

With these arrangements the maximum unloading per axle is about 700 kg (1 543 lbs.) and the coefficient of utilisation of the adhesive weight is 95.8 %, Nos. 2 and 3 axles in the direction of running being the least loaded.

It must not be overlooked that as the suspension of the body is not statically determined because of the vertical coupling, it is not possible to fix beforehand the maximum possible reduction of weight corresponding to the different tractive efforts.

The body is elastically supported on three points on each bogie; two of the supports are placed on the two sides of the pivot (Fig. 29) and have springs (to allow some oscillation of the body trans-

versely) and the third point of support is on the inner headstock of the bogie as mentioned above and has an adjustable spring compensator to divide the load between the two bogies.

To help take the sharpest curves (to 100 m = 328 feet) the middle tyres have flanges 10 mm (0.394 inch.) thinner than the others.

complementary suspension of coiled springs so that the main springs do not deflect until the load exceeds a certain limit.

The principal characteristics of these bogies are given in Table IX :

Maintenance of bogies.

Bogie repairs are done during vehicle inspections and repairs when the mileage

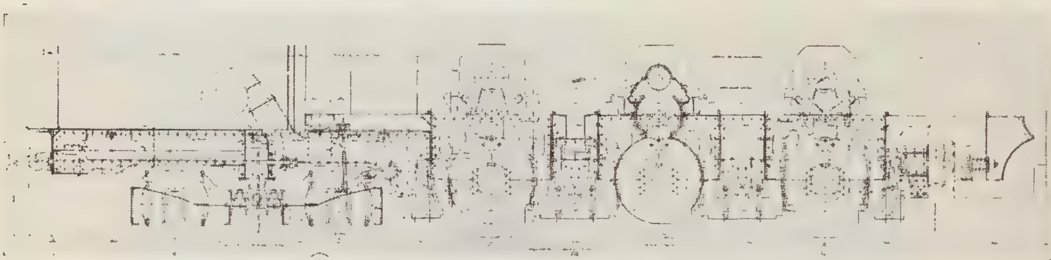


Fig. 26. — Locomotive series 7301. — Truck.

Fig. 27. — Locomotive series 7400.

given has been run. On the bogies of the C_0+C_0 locomotives many side frames have broken with the exception of the 7400 class which have now run 400 000 km (250 000 miles) without any crack having occurred in the side frames. Many cracks have also been found in the frames of the $2\text{-}C_0+C_0\text{-}2$ locomotives.

d) *Bogies of class 300 railcars* (Fig. 30).

The bogies under the recently built class 300 railcars are the following types :

Motor coaches : « Brill » 27 M. C. D. 4.
Trailers : « Brill » B. F. 104.

These bogies have a device for damping the movement of the pivot at starting and when running into curves as well as a

The 7400 class locomotives have been

fitted with an arrangement whereby in the event of slipping not being mastered the current to the traction motors is cut.

Stability of the vehicles when running.

The 7400 class C_0+C_0 locomotives run very steadily up to their maximum speed of 90 to 100 km/h. (56 to 62 m.p.h.). The $2\text{-}C_0 + C_0\text{-}2$ have a very marked nosing movement at speeds above 80 km/h. (50 m.p.h.). The rail motor coaches of class 300 run steadily up to 100 km. We think the play of the axles should be reduced to the minimum to improve stability when running but to facilitate their inscription in curves the class 7400, 7200, 7300 and 7500 locomotives have the flanges of the centre wheels thinner than the others.

Influence on the condition of the track of running electric vehicles and of the wheel diameter.

The Permanent Way Department has no comparative information on the cost of repairs on lines over which steam trains run as compared with those over which the electric trains run.

This Department has no precise data on the wear of the outer rail on curves in relation to the wheel diameter and there are no regulations fixing the said diameter in terms of speed and axle loading.

Future tendencies.

R. E. N. F. E. has ordered 20 locomotives of the C_0+C_0 type of 3 150 h. p., maximum speed 125 km/h. (78 m.p.h.), 3 000 V d. c., from the Alsthom Cy. The motors are to be fully suspended with the Alsthom drive as fitted to the CC. 7000 locomotives of the S. N. C. F. but with the axles driven at one end. The bogies will be of the same kind and the axle boxes connected to the frame by articulated rods fitted with silent-blocs.

Diesel-electric rail motor coaches.

R. E. N. F. E. has 10 Diesel-electric rail motor coaches, 7 of 400 h.p. and 3 of 300 h.p.

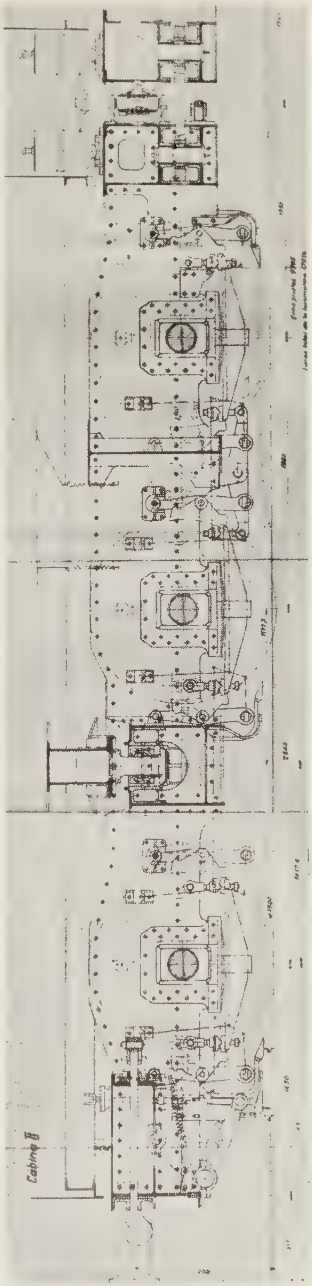


Fig. 28. — Locomotive series 7400. — Trucks.

Appendix No. 9 gives the leading dimensions of the Maybach 410 H. P. rail motor coaches.

The adhesive weight of these vehicles is about 22 000 kg (48 500 lbs.), and total weight in working order about 44 000 kg (97 000 lbs.). The tractive effort is 5 500 and 3 200 kg (12 125 and 7 050 lbs.) for the 400 and 230 H. P. railcars respectively at normal speed.

The traction motors are fitted to one of the two bogies of each railcar and are nose suspended. Roller bearing axle boxes are fitted. The brake is compressed air. These vehicles have been in service since 1935 and are satisfactory up to a speed of 110 km/h. (68 m.p.h.).

Catalan Railways.

The Catalan Railway Co. has been electrified with 1 500 V D. C., about 10 km (6 miles) of line with curves of 200 m (656 feet) minimum radius and gradients of 1 in 100. The gauge is 1 m (3′ 3 3/8″).

There are 4 B_0+B_0 train locomotives weighing 35 t with 4 nose suspended traction motors. The horse power at the tread (one hour rating) is 400. The tractive effort at the tread continuous rating is 4 500 kg (9 920 lbs.) and the speed at this rate is 40 km/h. (25 m.p.h.).

The gear ratio is 23/76 with straight toothed gears. The wheel diameter is 860 mm (33 7/8 inch.). The body is carried on two pivots at 6 m (19 feet 8 1/4 inch.) centres, and the bogie wheel base is 2.25 m (7 feet 4 9/16 inch.). The bogies of plate construction have bolsters and the Company is satisfied with the behaviour of the vehicles up to the maximum speed of 80 km/h. (50 m.p.h.).

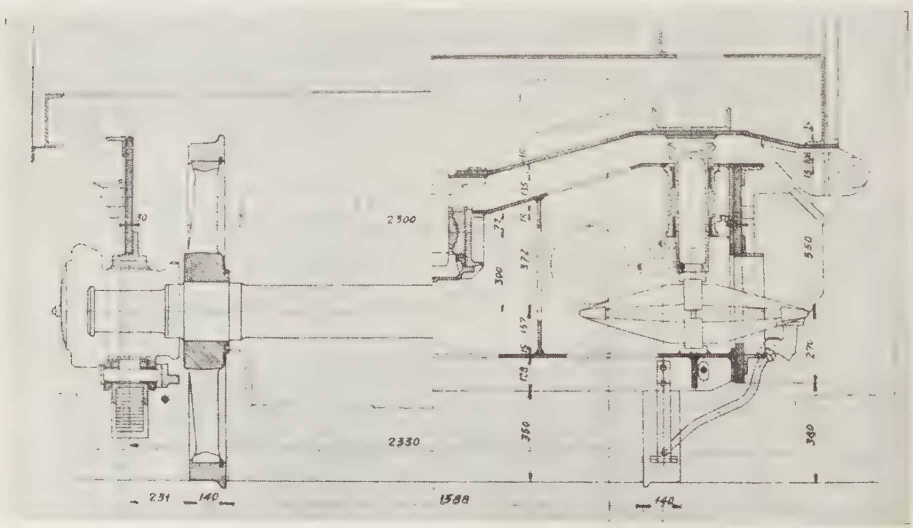


Fig. 29. — Locomotive series 7400. — Pivot and spring side bearings.

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CHAPTER III.

Some comments on the points dealt with in this report.

Before ending this report we feel some comments of a general nature are desirable on the points of this investigation.

A. Types of individual axle drive.

a) *Nose suspended motors.*

Nose suspension, very widely used in various countries, has amongst other advantages simplicity of construction and low cost of upkeep, but on the other hand the weights not spring borne are high and the shocks when running over joints between rails are reflected in fairly high costs of maintenance of the permanent way. The gears and motors are more exposed to damage. The use of elastic toothed gears can improve this type of suspension in some respects.

Fig. 30. — Series 300 motor coaches.

We think it advisable that locomotives with this type of suspension should be limited to a speed of 100 km/h. (62 m.p.h.), the weight be reduced to the minimum, and the support of the nose of the motor be given great flexibility. Under these conditions we consider this type of suspension is to be recommended.

b) *Fully suspended motors.*

We consider this system of suspension should be used on vehicles which have to exceed a speed of 100 km/h. (62 m.p.h.), especially on locomotives requiring high power motors. In these types particular attention should be given to the problems of wear (greater use of hard metals), lubrication and oil-tightness, whilst not overlooking the problem of good working.

In selecting any individual drive especially for bogie locomotives in which the motors are on the bogies the space in width needed for the drive plays a large part and can decide the type to be used.

In addition to the information about the drive referred to in this study, we think it proper to call attention to the good results in service of the Alsthom type of coupling between the quill and axle with free ring and rods on silent blocs on the 7011 and 7002 CC. locomotives of the S. N. C. F., the Brown Boveri disc drive on the Lötschberg Railway since 1944 which have run over 800 000 km (500 000 miles) with complete satisfaction, to the Brown Boveri elastic drive fitted to the R. E. 4/4 locomotive of the S. F. F. and to the Secheron drive by cardan shaft and plate couplings.

B. Bogies.

Until recent years it was considered necessary when taking curves at high speed that the vehicles should have a lighter load on the first pair of wheels, and that further the high speed locomotives should be fitted as a rule with a leading truck or bogie. In view of the desire to use to the maximum the weight of the locomotive it was decided to build for trial service high speed locomotives with the whole weight adhesive. The result was most happy as was demonstrated in particular by the B_0—B_0 locomotives of the Lötschberg with an axle loading of 20 t and capable of reaching a maximum speed of 126 km/h. (78 m.p.h.), the 7001 and 7002 C_0—C_0 locomotives of

TABLE IX. — **Principal charac**

R. E. N. F. E.	S. 6 000	S. 7 000
Type of bogie	Co—Co	Co+Co
Electric coupling of the motors fitted to a bogie	3 motors in series permanently.	3 motors in seri
Number of vehicles with this type of bogie : *In* 1940 *In* 1949	 6 6	 12 12
Diameter of the wheels (mm)	990	1 300
Load per axle	See appendix 6.	See appendix 7.
Distance between axles	See appeudix 6.	See appendix 7.
Distance between bogie pivots	8.016 m.	9.500 m.
Anti-hunting, anti-nosing transverse coupling?	None.	
Dampers		
With or without swing bolsters	Without.	With moveable
Frame construction		Rolled secti
Lateral support of the body on the bogies	Bearing surfaces.	Coiled springs on
Method of carrying the body on the bogies	No elastic suspension.	With elas

(1) Anti-hunting device on the carrying bogies of the 2—Co+Co—2 locomotives.

ogies considered.

S. 7 100	S. 7 200, 7 300 et 7 500	S. 7 400	S. 300 Rail motor coaches
1—Co+Co—1	2—Co+Co—2	Co+Co	Bo+Bo
permanently.	2 motors in series permanently (7 200 and 7 500) and 3 motors in series (7 300).	3 motors in series permanently.	2 motors in series permanently.
25 25	13 25	— 22 and 2 to be supplied.	48 78
1 300 motor 1 036 guiding	1 560 motor 860 guiding	1 300	996
;ee appendix 7.	See appendices 7 and 8.	See appendix 8.	See appendix 9.
;ee appendix 7.	See appendices 7 and 8.	See appendix 8.	See appendix 9.
9.500 m.	9.750 m·	9.705 m.	12.950 m.
	With transverse coupling (1)		Anti-hunting.
Without (1).			With.
ster	Without.		With.
l plates.		Rolled sections and welded plates.	Rolled sections and plates.
oveable bolster.	Coiled springs at each corner of the body.	Elastic supports on each side of the pivot.	Swing bolster and links.

pension.

TABLE IX. — **Principal charac**

R. E. N. F. E.	S. 6 000	S. 7 000
Type of bogie	Co—Co	Co+Co
Way body carried on bogie		On inside bearings
Type of axle box		
Axles : a) *Material used*.		Carbon steel R
b) *Pressure of press fits (t)*.	75	
c) *Broken axles*	None.	
Method of suspension of bogie frames on wheels. . .		Lamina
Particulars of springs : a) *Maximum deflection (cm)*	7	9
b) *Flexibility in cm per t*.	0.85	0.7
Method of guiding axle boxes.		All the box
Play between guides and boxes	Play only provided to prevent boxes seizing up in t	
Results obtained with these bogies : a) *Costs of maintenance*	Low.	
b) *Cost price*	Low.	Average.
c) *Satisfactory riding up to a speed of*.	60 km/h.	75 km/h.

e bogies considered *(continued)*.

S. 7 100	S. 7 200, 7 300 et 7 500.	S. 7 400	S. 300 Rail motor coaches
1—Co+Co—1	2—Co+Co—2	Co+Co	Bo+Bo
cing of the wheels.			
arings.			Plain and roller bearings
48 kg/mm^2, A $\geqslant$ 23 %.			
		90	75
	Yes (7 300) None (7 200 and 7 500)	None.	
springs.			Coiled springs.
	8.3	8.2	5
	0.84	0.7	0.9
led by slides.			
guides. The side play between the axle boxes and the guide is $\pm$ 0.5 mm.			
eavy.		Very low.	Low.
Average.	Dear.	Average.	Low.
75 km/h.	100 km/h.	100 km/h.	110 km/h.

the S. N. C. F. with an axle loading of 16.8 t tested with very satisfactory results up to a speed of 160 km/h. (99 m.p.h.), and the Italian locomotives E 424 and E 636 with axle loads of 18.1 and 16.8 t respectively and having a maximum speed of 140 km/h. (87 m.p.h.).

As Dr. Gaston BORGEAUD pointed out in his paper given before the Institution of Locomotive Engineers in London in January 1949, to obtain good running stability the following conditions must be satisfied :

a) the locomotive should pass freely through all curves;

b) the forces between the wheel and the rail on curves at the allowed speeds should not reach excessive values;

c) the vertical and lateral shocks produced by the inevitable irregularities of the track should be reduced to the minimum;

d) on the straight the guiding of the locomotive should be such that its running qualities are the best possible; all secondary harmful movements should be suppressed.

To meet the first two conditions, 2 axled bogies or 3 axled bogies with the intermediate axle with side play to allow in this case the tyre to bear on the rail without setting up harmful forces in the frame of the bogie; this would ensure the thrust of the wheel on the rail being similar those set up by two wheeled bogies.

We also consider it desirable to couple the bogies together transversely to reduce the guiding effort and the angle of attack of the wheel on the rail which results in less wear of the flanges.

Under conditions *c*) and *d*) mentioned above, the types of springing of the locomotive and of the traction motors, the type of drive, axle play, and the state of repair of the track all play a part.

We feel that for high speel C_0-C_0 locomotives of high power it is also well to take into account the following conditions :

a) central position of the bogie pivot; if the pivot be placed between the first and second axle the guiding effort of the first axle is too great;

b) long distance between pivots; that is to say buffing and drawgear fastened to the body of the locomotive;

c) as far as possible an adequate transverse coupling between the two bogies to facilitate the running of the locomotive on curves;

d) give play to the centre axle (within certain limits), to enable this to bear on the outer rail when running over curves to prevent the lateral thrust of this axle being taken by the bogie frame;

e) provide a simple elastic connection between the body and the bogies to prevent too great transverse inertia forces. This connection can be obtained by a pendulum suspension (7001 and 7002 C. F. F. locomotives), or with the Alsthom elastic self centering arrangement as fitted to the S. N. C. F. high speed C_0-C_0 locomotives;

f) connecting the axle boxes to the frame by hinged rods and silent blocs, to reduce to a minimum upkeep and wear and prevent all play between the axle box and the frame so harmful as regards stability.

Another system for maintaining the boxes which has also given excellent results with silent-blocs is fitted to the Re 4/4 locomotives of the C. F. F.

If the classic system with guides is used they should be protected from dust and be kept in an oil bath;

g) avoid an excessive unloading of the leading axle;

h) as far as possible the suspension of the body should be isostatic to avoid excessive overloads;

i) for good running both the centre of gravity of the bogie and that of the body should be as high as possible without exceeding certain values;

j) use of bogies of welded construction of box sections of high vertical and transversal rigidity.

* * *

SUMMARY.

A. Italian State Railways.

The length of lines electrified at 3 000 V D.C. amounts to 4 019 km (2 500 miles); the total number of locomotives in service is 906 and there are 212 railcars with 62 now being delivered.

The first locomotives to go into service were the classes E. 626 ($B_0+B_0+B_0$), E. 326 ($2\text{-}C_0\text{-}2$), E. 428 ($2\text{-}B_0+B_0\text{-}2$), but as from 1940, class E. 636 ($B_0\text{-}B_0\text{-}B_0$) began to come into service. These locomotives were designed to eliminate some of the drawbacks of the previous types and also in order to have available locomotives utilising their whole weight for adhesion and having a statically determined distribution of the weight over the axles.

With the same object in view, class E. 424 (B_0—B_0) locomotives were put into service in 1943; this type was equipped with bogies and other, both mechanical and electrical parts, identical to those on the E. 636 class in accordance with the standardisation schemes of the Rolling Stock Designing Office.

The percentage of each type of drive as compared with the total number of axles in use in 1949 is as follows :

a) locomotives. Nose suspended, 55.4 %; Bianchi drive, 18.4 %; Negri drive, 26.2 %;

b) Railcars. Nose suspended, 12.9 %; Bianchi drive, 73.3 %; Negri drive, 13.8 %.

Results obtained in service with the different drives.

a) *Nose suspension.* Satisfactory results up to 100 km/h. (62 m.p.h.) on locomotives and 120 km/h. (75 m.p.h.) on rail motor coaches;

b) *Bianchi and Negri plate drives.* Excellent results up to 200 km/h. (124 m.p.h.);

c) *Negri coiled spring drive.* As from 1945 abandoned owing to the cost of repairs through the wear of certain parts;

d) *Rod suspension on ALe 840 rail motor coaches.* Excellent results up to 140 km/h. (87 m.p.h.); not tested at higher speeds.

In general there have been no broken teeth nor axles, but several cases of broken spring plates in the Bianchi and Negri drives as well as appreciable wear owing to the difficulty of lubricating the parts.

Results from the different types of bogies.

The bogies under the E. 626 locomotives give satisfactory results up to 100 km/h. (62 m.p.h.); those under the E. 636 and E. 424 behave satisfactorily too up to the maximum speed of 140 km/h. (87 m.p.h.) and the costs of repairs are less than those of the E. 626 type.

The rail motor coach bogies are satisfactory up to 140 km/h., and those of the E. T. R. motor rakes (Elettrotreni) can reach a speed of 200 km/h. but the costs of repairs to this latter type of bogie are rather high.

On the other hand the cost of repairs to the new type of bogie of the ALe 840 rail motor coaches is much reduced.

Materials used.

The gears are straight toothed. The toothed wheels are made of Ni-Mo steel not heat treated and the pinions of Cr-Ni oil hardened.

The axles of the ETR rail motor coaches are made of Cr-Ni-Mo steel and for the other vehicles of carbon steel.

Behaviour in service.

From the point of view of the Permanent Way, the wholly suspended motors are better although is has not been possible to draw definite conclusions as to the effect of running electric stock on the cost of maintenance of the permanent way.

The stability of the vehicles at the speeds considered is satisfactory.

Diesel electric locomotives.

The Italian State Railways only possess Diesel-electric shunting locomotives.

B. North of Milan Railway.

This Railway has 120 km (75 miles) of line electrified at 3 000 V D. C., and the service is worked by 6 locomotives of the E 600 class (B_0+B_0) and 25 rail motor coaches of the E 700 and E 730 classes both B_0-B_0.

The drive is by nose suspended motors with straight toothed gears with the exception of the E 730 railcars (3 in use) on which the motors are fully suspended with quill and elastic toothed gears with oblique teeth.

The designed speeds were 85 km/h. (53 m p. h.) for the locomotives and 100 km/h. (62 m.p.h.) for the rail motor coaches. The results given by the drives and by the bogies are satisfactory.

C. Portuguese Railways.

There are no electric locomotives nor rail motor coaches. There are 12 Diesel-electric locomotives of 1 500 H. P. which have been, in use for a year; these have 3 axled bogies, and at the moment an investigation is being made to correct the excessive transversal motion observed.

D. Spanish National Railways (RENFE)

The length of line electrified at 1 500 V D. C. is about 1 000 km (620 miles); there is in addition 62 km (39 miles) at 3 000 V D.C., and 30 km (19 miles) electrified in 1911 with 6 000 V 25 periods three phase A. C.

The total number of D. C. locomotives is 110 and there are 92 electric rail motor coaches on 1 500 V D. C. of which 78 (class 300) are formed into permanent twin coach sets, one motor and one trailer.

The most used bogie is the three-axle type but in the case of locomotives intended mainly for passenger work the classes 7200, 7300 and 7500 2-C_0+C_0-2, are used.

76 % of the locomotive axles have nose suspended motors, but the 2-C_0+C_0-2 classes 7200 and 7500 have the Brown Boveri-Buchli drive between the wheels, and drive at both ends. The number of axles driven by the Brown Boveri drive is 23.1 % of all locomotive axles.

On the 7300 class locomotives with the same trucks as those under the 7200 and 7500 classes, the Winterthur drive with twin motors is used.

On the electric rail motor coaches the bogies of the motor coach are the Brill 27 M C D. 4 type and those of the trailer the Brill B F. 104. All the motors on the rail motor coaches are nose suspended with oblique toothed gears.

Service results of the different drives.

a) The nose suspension gives good results up to 80 km/h. (50 m.p.h.) on the locomotives and 100 km/h. (62 m.p.h.) on the rail motor coaches. It is found however that this drive causes rather more cases of damage to motors than when the fully suspended motor drive is used;

b) the Brown Boveri drive has caused damage through failure of the elastic pinion and in 1949 on the 7500 class locomotives (with an average distance run since their introduction of 400 000 km [250 000 miles]) the number of broken pinions on the motor axles is 5 %;

c) the Winterthur drive on locomotive 7301 has given a very good result.

Results with three axle bogies.

On all the locomotives, with the single exception of the 7400 class, many cracks have been found in the bogie side frames.

Behaviour of the vehicles in service.

The class 7400 C_0+C_0 locomotives are very steady up to 90 to 100 km/h. (56 to 62 m. p. h.), whereas the 2-C_0+C_0-2 locomotives have a very marked hunting motion at speeds over 80 km/h. (50 m.p.h.). The middle axle on the 7400, 7200, 7300 and 7500 classes have the flanges reduced by 10 mm (0.394 in.) to enable the locomotives to pass through a curve of only 100 m (328 feet) radius.

Diesel-electric rail motor coaches.

R. E. N. F. E. has 10 Diesel-electric rail motor coaches with 4 wheeled bogies and nose suspended motors. They behave satisfactorily up to 110 km/h. (68 m.p.h.).

E. Catalan Railways.

The Catalan Railways have 10 km (6.2 miles) of line electrified at 1 500 V, the gauge being 1 m (3′ 3 3/8″).

The trains are worked by four B_0+B_0 locomotives of 35 t, 400 H. P. with 4 nose suspended traction motors. These locomotives run satisfactorily up to 80 km/h. (50 m. p. h.).

F. Some observations on the points covered in this report.

We consider that the speed of vehicles with nose suspended motors should not exceed 100 km/h. (62 m.p.h.) and, by reducing the unsprung weight as much as possible using very flexible supports for the motor nose and flexible toothed gears, this type of drive is to be recommended.

For locomotives running over 100 km/h. (62 m.p.h.) fully suspended motors should be used.

In view of the results obtained in service with 2 and 3 axled bogies, with the whole weight available for adhesion, we consider that guiding trucks or bogies can be eliminated.

motives we recommend :

For high speed and power C_0—C_0 loco-

a) central position of the bogie pivot;

b) draw and buffer gear on the body of the locomotive;

c) simple flexible attachment of the body to the bogie;

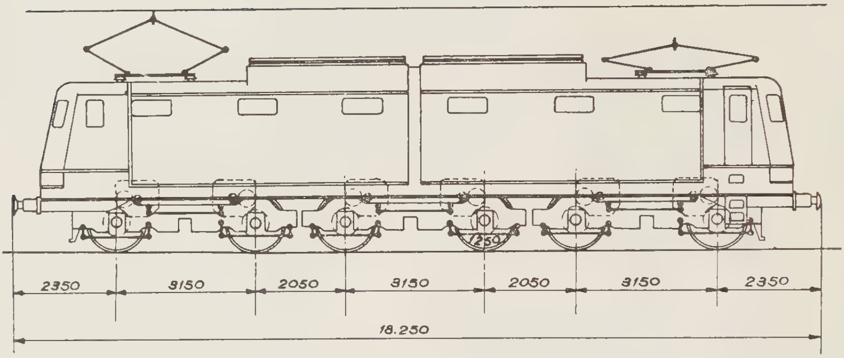
d) connection of the axle boxes to the bogie frames by means of articulated links with silent bloc bushes;

e) use of bogies of welded construction with box section side frames.

Madrid, 3rd April 1950.

Appendix 1.

E636



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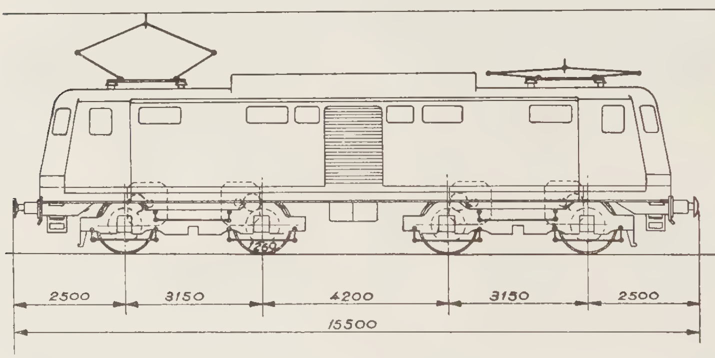

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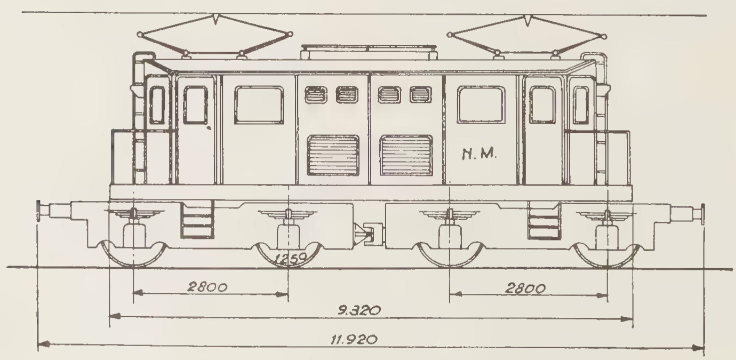
E600



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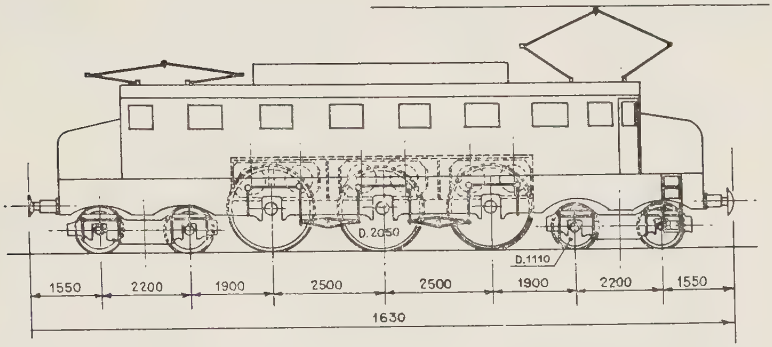
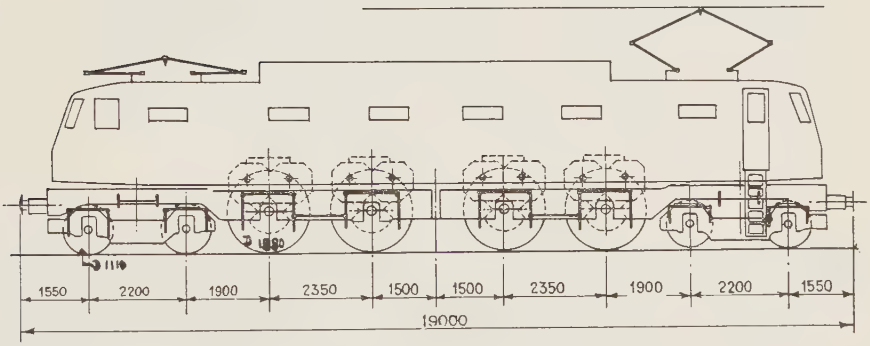
Appendix 2.

E.326



E.428



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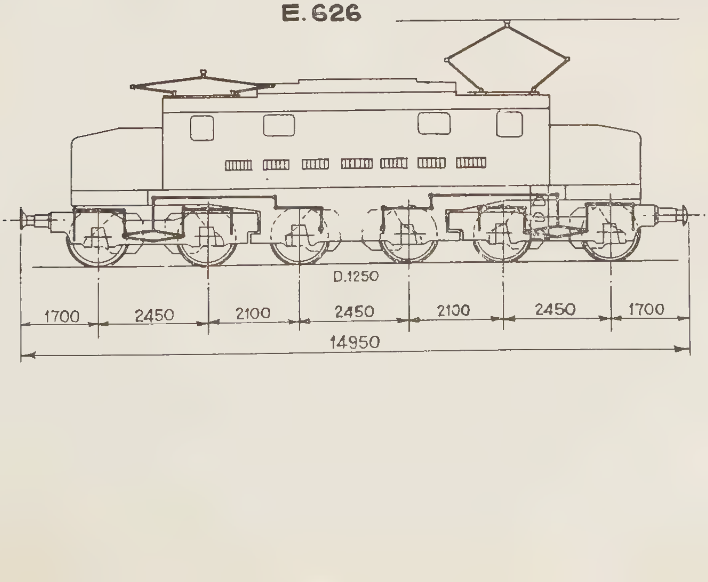
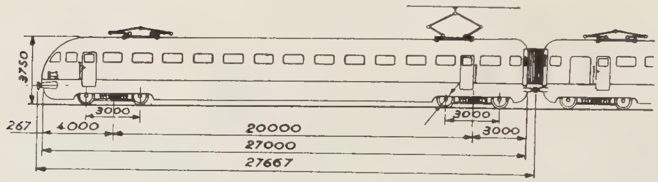
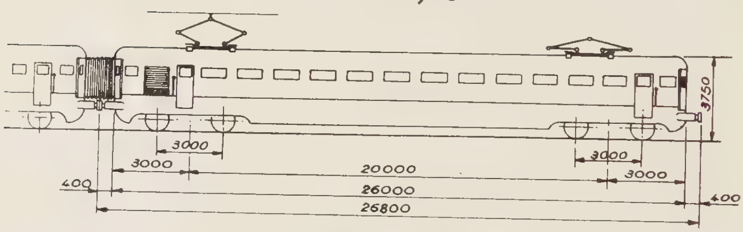


Appendix 3

A Le 3-series motor coach.



ALe 790/880



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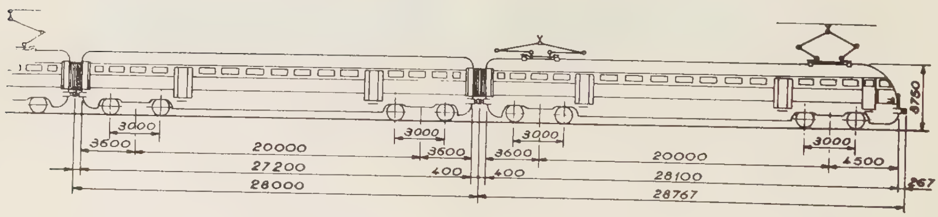
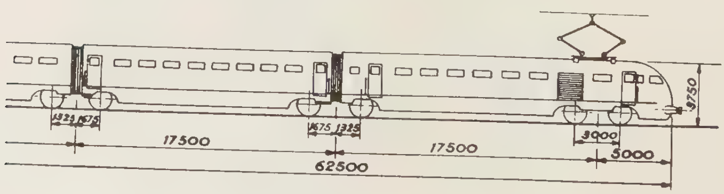
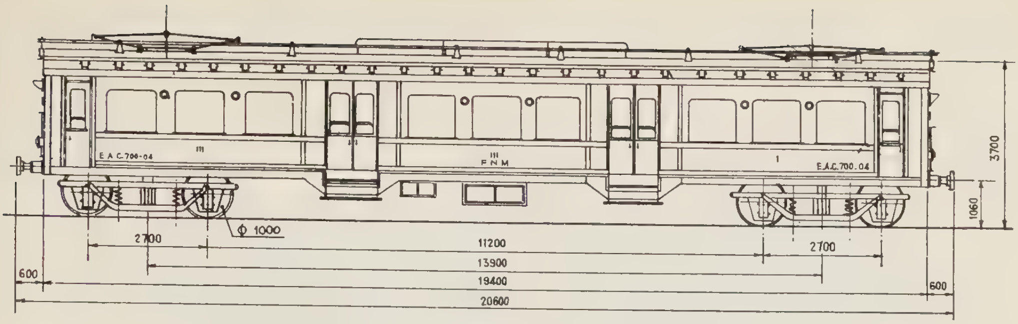


ETR-200

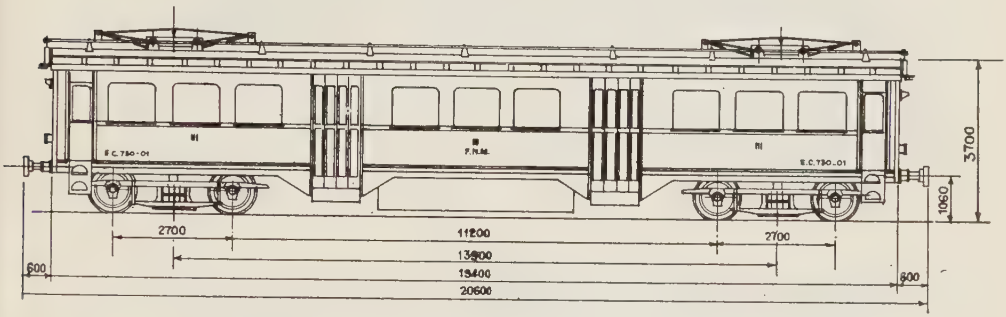


FS

E 700



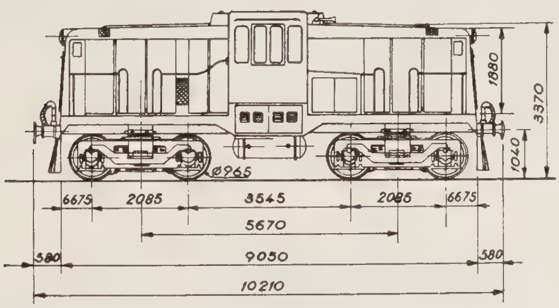
E 730



Portuguese Railways. — Diesel-locomotive for shunting. *Appendix 5.*

Chemins de fer Portugais - Locomotive Diesel pour triage

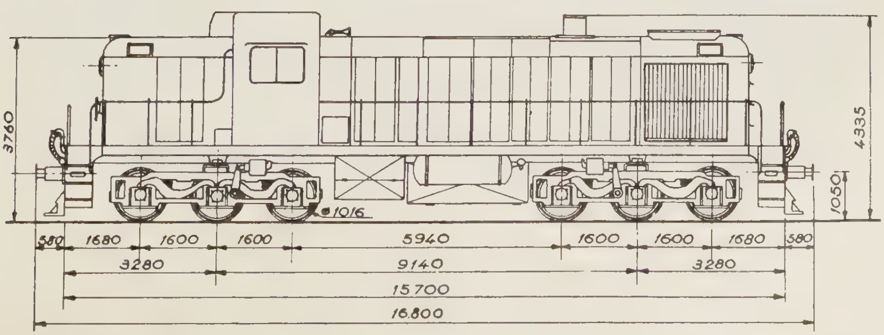
SERIE 1 - 12



Portuguese Railways. — Diesel-electric locomotive series 101 and 1101

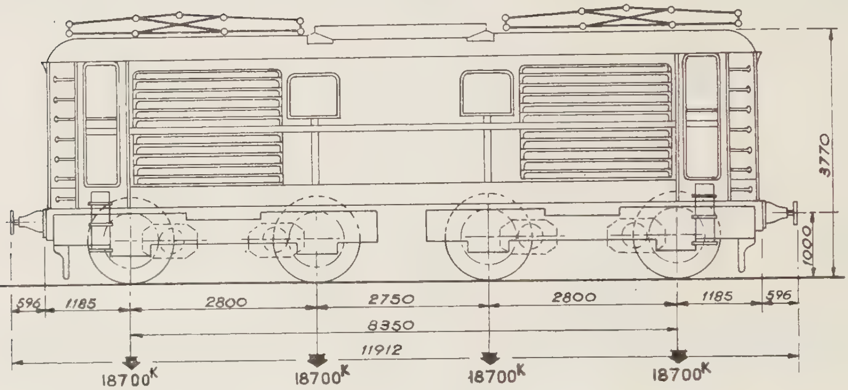
Chemins de fer Portugais-Locomotive Diesel Electrique

SERIE 101 et 1101

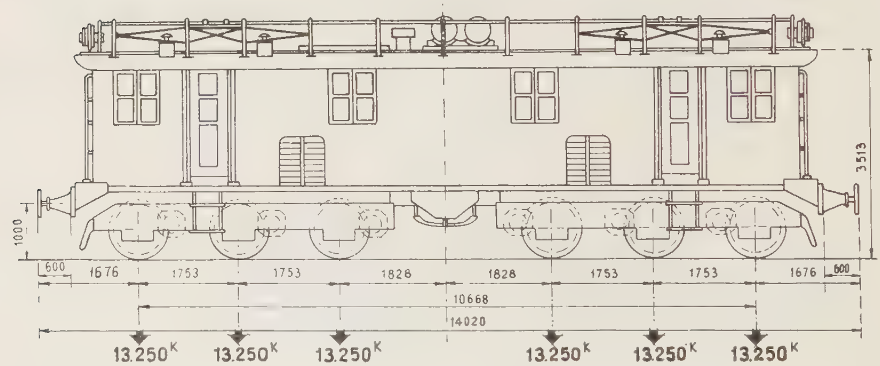


Appendix 6.
R. E. N. F. E

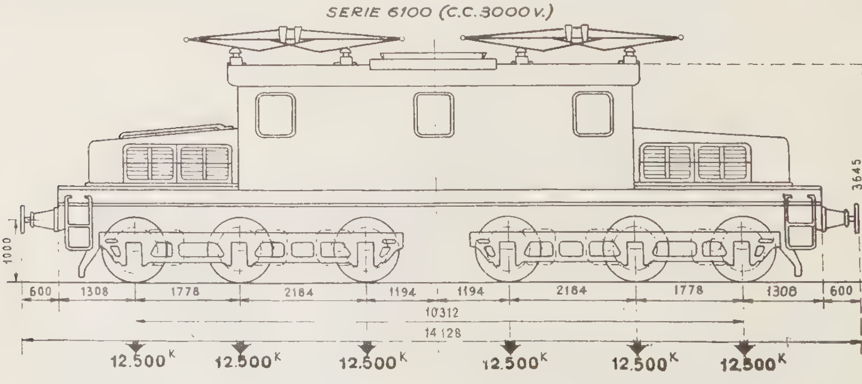
SERIE 1000 (C.C. 1.500 V.)



SERIE 6000 (C.C. 3000 V.)



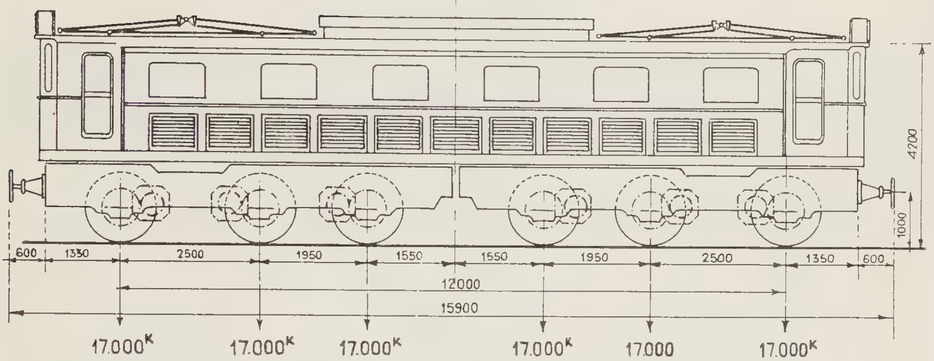
SERIE 6100 (C.C. 3000 V.)



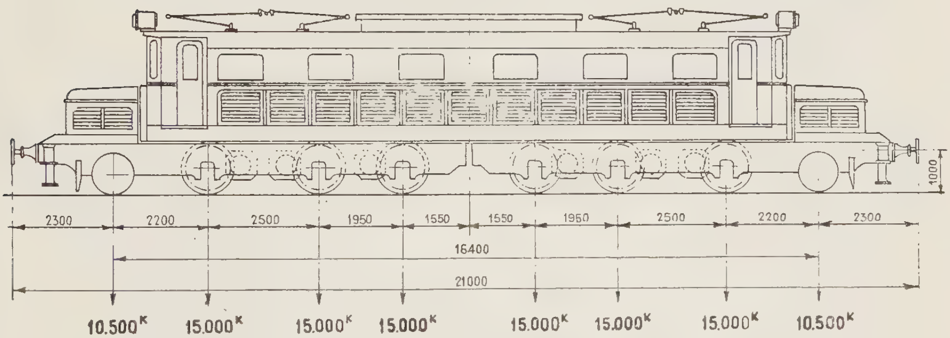
Appendix 7.

R. E. N. F. E.

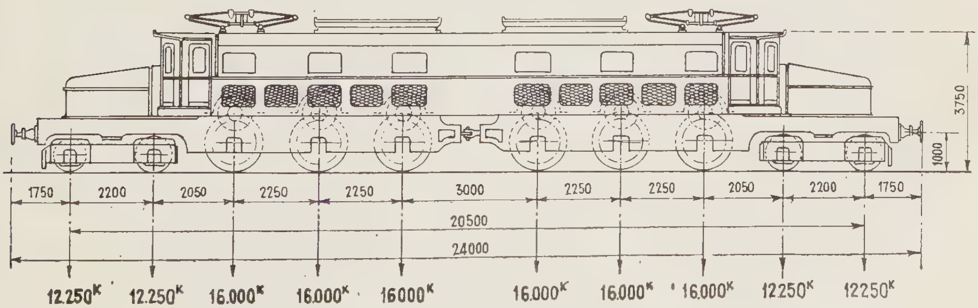
SERIE 7000 (C.C.1500 V.)



SERIE 7100 (C.C.1500 V.)



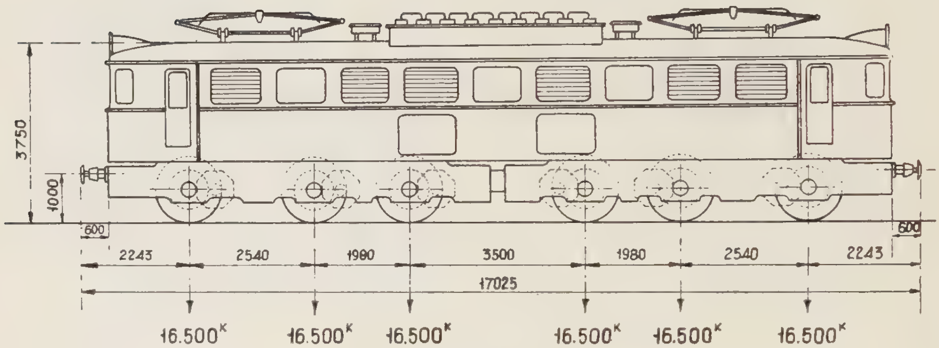
SERIE 7200 (C.C.1500 V.)



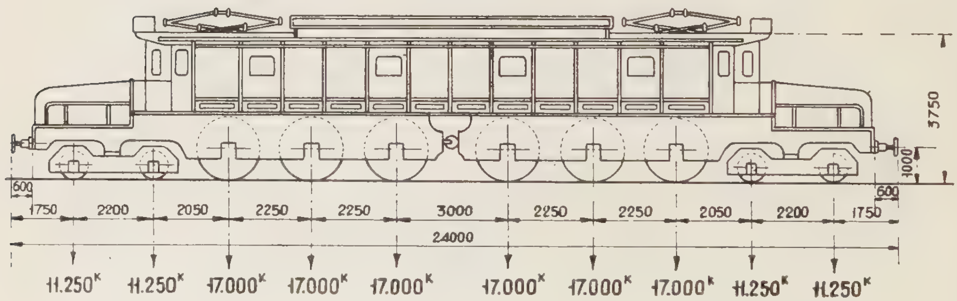
Appendix 8.

R. E. N. F. E.

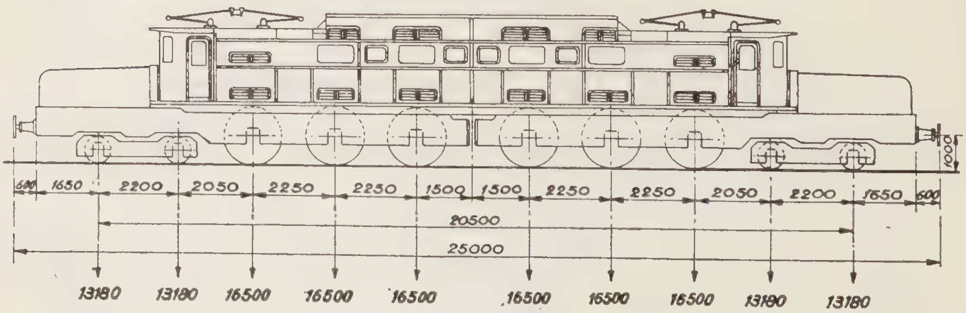
SERIE 7400 (C.C.1500 V.)



SERIE 7500 (C.C.1500 V.)



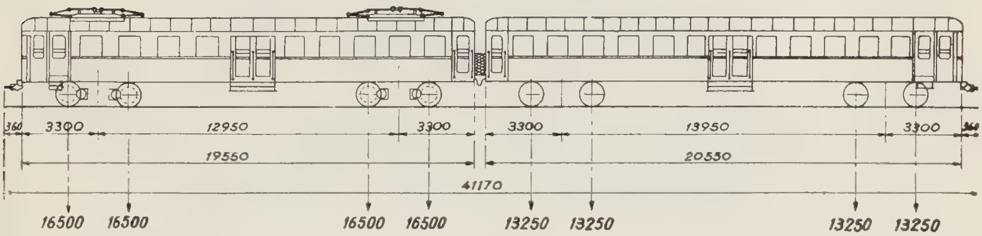
SERIE 7300 (C.C.1500 V.)



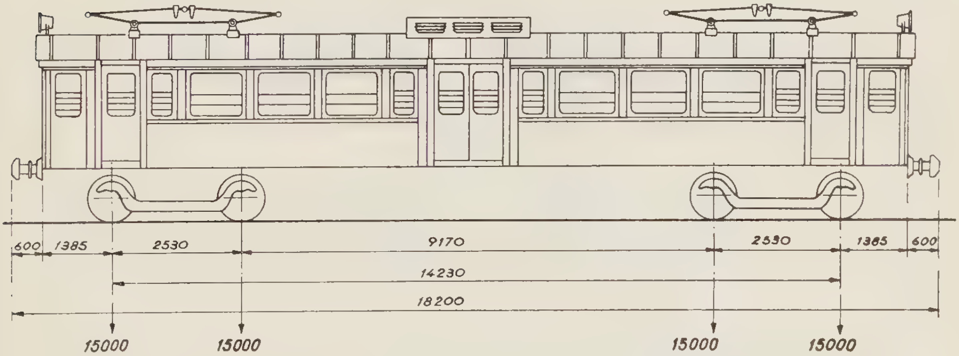
Appendix 9.

R. E. N. F. E.

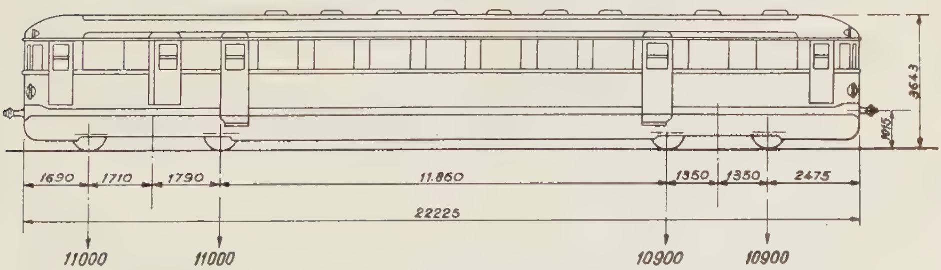
AUTOMOTRICE SERIE 300 (C.C. 1500 V)



AUTOMOTRICE SERIE 500 (C.C. 1500 V.)



AUTOMOTRICE DIESEL ELECTRIQUE SERIE 9400



Series 800 (C. C. 1500 V) Motor coach.

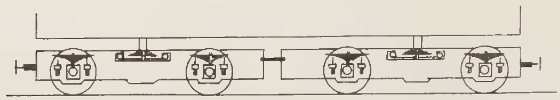
Series 500 (C. C. 1500 V) Motor coach.

Series 9400 (C. C. 1500 V) Diesel-electric motor coach.

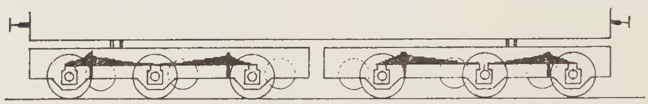
Appendix 10.

R. E. N. F. E.

SERIE 1000 Y 1.100



SERIE 6.000



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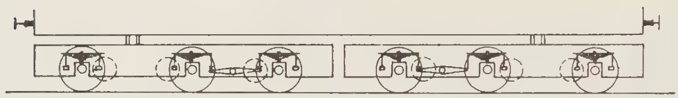
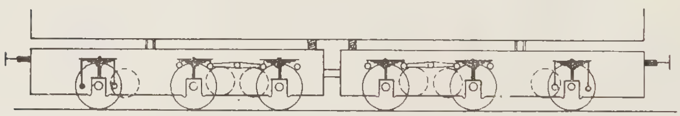
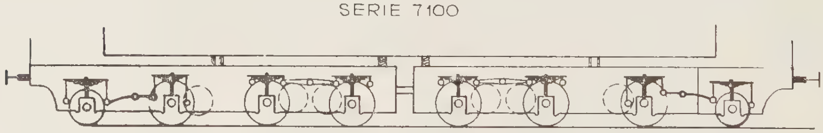


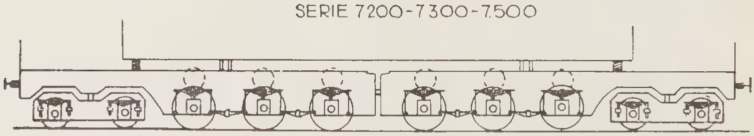
SERIE 7000



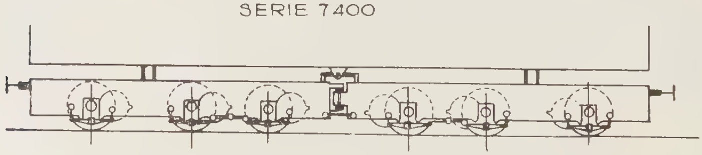
SERIE 7100



SERIE 7200-7300-7.500



SERIE 7400



[625 .2]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

15th. SESSION (ROME, 1950).

QUESTION IV.

The comfort of passengers in coaches, railcars and electric motor coaches:

Sound proofing;
Lighting;
Heating, air conditioning, ventilation, thermic isolation;
Upholstery;
Running stability (type of bogie and suspension).

REPORT

(America (North and South), Great Britain and North Ireland, Dominions, Protectorates and Colonies, China, Burma, Egypt, India, Pakistan, Malay States, Iraq and Iran),

by E. F. Loquet,

Ingénieur à la Société Nationale des Chemins de fer belges.

INTRODUCTION.

The questionnaire for Question IV dealing with the comfort of passengers was sent to 14 Administrations, 8 of which replied, these being:

British Railways (Railway Executive) (B. R.);

London Transport Executive (L. T. E.);

The Pennsylvania Railroad Cy (Penna);

South African Railways and Harbours (S. A. R.);

Victorian Railways (V. R.);

Government of India, Ministry of Railways (I. R.);

Government of New Zealand Railways (Z. R.);

Ceylon Government Railway (C. R.).

Sudan Railways.

The present report is divided up into the 5 following parts:

A. — Sound deadening;

B. — Lighting;

C. — Heating, Ventilation, Air Conditioning, Heat Insulation;

D. — Fittings.

E. — Running stability.

Each of these parts is subdivided into 3 chapters dealing with the different categories of stock:

Chapter I. — Coaches;

Chapter II. — Railcars, driven by heat engines;

Chapter III. — Rail motor coaches, driven by electric power, either from a third rail or overhead line.

***

A. SOUND DEADENING.

1. Methods employed to stop causes of noise.

Coaches, railcars and rail motor coaches.

With one exception no Administration has tried elastic wheels. The trials carried out by the L. T. E. (London Subway) showed that the diminution of noise compared with ordinary steel disc wheels is not appreciable.

In addition, this Administration doubts whether elastic wheels will stand up to the severe operating conditions due to the high temperatures obtained on the tyres owing to the frequent application of the brakes. The tyres cool down badly owing to the rubber joints inserted between the wheel centres and the parts carrying the tyres.

The L. T. E. no longer fits brake rigging on the bodies of recent stock. There is brake gear on each bogie and the noise due to the long rods and their joints has been got rid of. Generally, the other Administrations limit the noise due to wear in the pin joints by fitting hard steel bushes and pins, adjusted and fitted with fitting tolerances. Frequent replacement of worn parts in the joints limits the noise due to them. Parts of the brake rigging which are likely to come in contact with the body or bogie are covered with leather or rubber sleeves; while parts in contact are covered with wood or autolubricating material (Ferodo), or else in rubber.

Vibrations due to the steel body sheets are lessened, either by decreasing the unsupported area of such sheets or by the application of a layer of asbestos by spraying, the thickness of which may vary between 1/8″ and 5/8″, or by the application of bituminised cork. The L. T. E. and V. R. put a layer of a bituminised solution of asbestos between the floor and the supporting steel plate; the plate carrying the floor is often separated from the steel components of the frame by a layer of the same solution.

As regards the heat engines of railcars, the B. R. recommend the use of intermediate gears with helicoidal teeth for driving the valve gear and injection pump, cut in two at right angles to their axis. The two toothed wheels obtained in this way are mounted on a common axis, sliding on this axis in relation to each other. Fixed studs on one of the toothed wheels enable the other toothed wheel to slide whilst rotating at the same speed. Springs fitted between the two toothed wheels tend to keep them apart and take up any play between the driven toothed wheels and the intermediate wheel (see fig. 1).

The Penna is of the opinion that the most effective measures to diminish noise are :

1) careful static and dynamic equilibration;

2) and adequate design of the exhaust pipe.

The equilibration visualised under 1) is mainly due to the need for having a smooth running engine; an engine that vibrates a lot owing to a want of balance is also affected to a greater extent by alternating deflections and torsion.

The principal steps taken to diminish the noise due to the gears and steering are in the former case the adoption of helicoidal gears and in the latter the use of pinions and toothed rings with rectified spiral teeth. The shafts carrying the gears should be fitted with ball bearings to get greater preciseness in centering the gears.

As special measures the B. R. have used preselective gearboxes with epicyclic constant mesh gears; helicoidal gears with rectified chevron teeth are recommended for the auxiliary gearboxes, the point of the chevron is replaced by a groove to enable the rectifying tool to be removed.

The L. T. E. state that an angle of 7 1/2° of cant for the helicoidal teeth has been found very effective in reducing noise.

The Penna is of the opinion that the boxes in which the gears are enclosed

reduce the level of noise to such an extent that it is not necessary to take any other steps.

2. Steps to prevent the propagation of noise.

I. — *Coaches.*

The Penna, B. R., S. A. R., L. T. E. and Z. R. fit rubber or other similar material between the frames of coaches and the bogies.

Elastic materials of this kind are fitted either at the feet of the bogie or between the body and bogie bolsters near the rubbing plates, or at both these points.

The bogie suspension is completed by rubber supports for the laminated springs or helicoidal spring. The B. R. have added rubber springs to the laminated springs attached to the spring links. The Z. R. did not mention any such special devices.

The use of solutions of asbestos compounds, either bituminised or not, sprayed on the inside of outer metal sheets, the thickness of which varies between 1/8″ and 5/8″, is fairly general; the layers applied to the roofs are thicker, from 1/2″ to 1″. The floors are fitted with a layer of cork which may be as much as 13/16″ thick. The B. R. completes this insulation by 1/4″ thick layer of bituminised asbestos compound on the outside of the steel sheet carrying the floor. The C. R. in their 1st and 2nd class compartments fit a 5/8″ thick layer of Celotex or sawdust packed between two steel sheets.

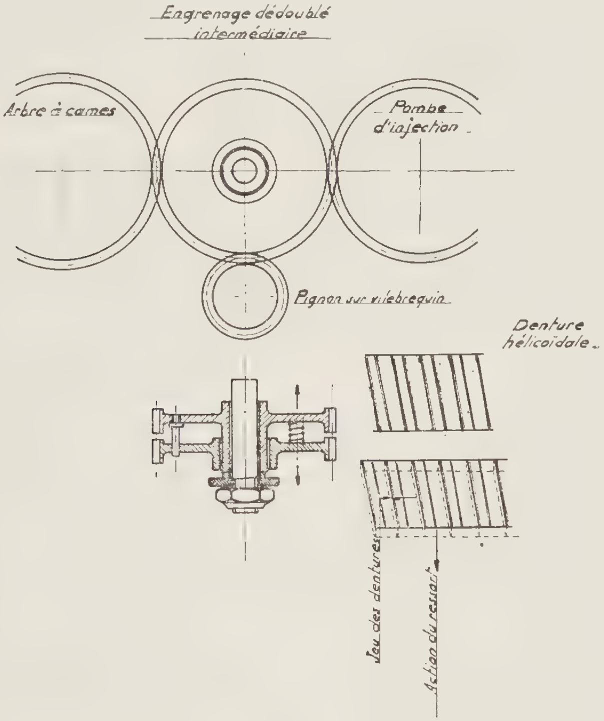


Fig. 1.

Explanation of French terms. — Engrenage dédoublé intermédiaire = Double intermediate gear. — Arbre à cames = Camshaft. — Pompe d'injection = Feed pump.— Pignon sur vilebrequin = Pinion on crank shaft. — Denture hélicoïdale = Helicoidal teeth. — Jeu des dentures = Play in teeth. — Action du ressort = Line of action of spring.

In the sleeping cars of the B. R., there is a 1/8″ thick layer of asbestos between the partitions between the berths and a 1/8″ thick layer of felt between the inner and outer sides of the longitudinal corridor partitions.

II. — *Railcars.*

To diminish the transmission of vibrations from the engines to the body, rubber fittings are generally used. The B. R. has adopted the so-called « floating » arrangement, i. e. the alignment of the front and rear supports is taken through the centre of gravity of the engine, and the rear support is fitted around the universal joint in such a way that any movement of the cardan shaft is impossible. The Z. R. mount the exhaust on a Ferodo fitting, and it is also fitted with a silencer and the air for the engines is drawn in through the roof over an oil bath. Vibrations of the outer sheeting, roofs and floors are prevented in the same way as with coaches.

III. — *Electric rail motor coaches.*

The propagation of noise in the bodies of rail motor coaches is prevented by the same methods as are used in the case of coaches and railcars.

No special measures are taken as regards the suspension of the engines. In the case of geared transmissions, rectified helicoidal teeth are generally used.

3. (I, II, III.) **Measuring the noise.**

In 1938 and 1939, the L. T. E. measured the noise due to running through tunnels. The audiometer used covered the scale of frequencies between 50 and 10 000 periods. The measurable level of noise lay between 60 and 140 phons. The microphone used had a characteristic straight horizontal response of 40 to 5 000 per./sec.; the control and amplification factors closely imitating the behaviour of the human ear at different frequencies.

It was very difficult to make comparative measurements and bring out the efficiency and effects of the different solutions tried; only very general measurements could be taken. The results were :

Average noise running in a tunnel . . . . 91-97 phons.

Noise when standing in a tunnel (compressors, generators, etc.) . . . . . 57-80 phons.

The B. R. made some extensive measurements in 1935 with an audiometer. The efficiency and effects of :

1) wheels with wooden centres;

2) floor with wood and with cork coverings;

3) asbestos compound sprayed onto the outer steel sheets of metal bodies;

4) casing in the bogies with metal fittings lined with asbestos compounds on the inside;

were determined in this way.

Other measurements covered the effect of elastic wheels, the window and door fastenings, the effect of double glazed partitions and the effects of different types of ballast : stone, slag, cinders, etc.

The main results of these experiments were :

1) the use of asbestos compounds reduces the level of noise by 7 phons;

2) encasing the bogies was very effective in diminishing noise, but the asbestos fittings were constantly deteriorating in service. This arrangement had no effect on the heating of boxes.

The results obtained from the tests showed that the cost of generalising the use of these arrangements would not be covered by an increase in the traffic.

We give below a few typical figures concerning the level of noise :

Basic level for a vehicle running at 60 m.p.h. on rails without joints . . . . . 70 phons.

Increase due to other influences :

Rail joints	5-7 phons.
Brake rigging	2-3 phons.
Vibrations of the outer steel sheets, panelling, etc., up to	4 phons.

Reductions obtained by different measures :

Encasing the bogies . . .	6-10 phons.
Covering the panels with sprayed asbestos . . .	3 phons.
Double glass	4 phons.

The separate effects are not additional.

* * *

B. LIGHTING.

1. Characteristics of sources of supply.

The characteristics of the sources of supply and batteries are collected together in Table I for the different Administrations.

The general conclusions to be drawn from the different replies are :

a) the most general source of supply for independent units is the shunt dynamo with automatic field regulation; transmission of power by flat or V belt. Transmissions by cardan shaft and gear box are only considered in the case of high powers (above 5 kW), in particular in the case of coaches equipped with air conditioning;

b) lead batteries are still the most widely used, but the use of alcaline, nickel-iron or cadmium-nickel batteries is beginning to increase;

c) the different Administrations prefer to recharge their batteries automatically from the generator on the vehicle, and not by means of fixed installations. The reasons are : lack of flexibility in operation and the impossibility of providing fixed charging plant at the ends of each line.

As regards the supply of current for fluorescent lighting in particular, 220 V — 60 per./sec. A. C. is most widely used. However the L. T. E. uses 110 V — 850 per./sec. current. The current is produced by transformers.

2. Incandescent lighting equipment.

Table II shows the arrangements adopted for different types of vehicles.

The following conclusions result from the replies to the questionnaire :

a) the use of reading lamps which can be lit by the passengers is widespread on main line stock;

b) the normal lighting is always fitted on the ceiling;

c) the methods adopted to prevent the bulbs being stolen are the use of a different voltage to the public supply and also the use of bayonnet type caps where the public supply uses the Edison screw type and vice versa as in England;

d) the shades are made of sanded glass or else frosted bulbs are used:

e) no protection against shocks is provided.

3. Fluorescent light equipment.

The S. A. R. make use of standard tubes 24″ long arranged in the rail motor coaches in a continuous line along the centre of the vehicle. Main line compartments have 2 groups of 2 tubes per compartment in the case of the 1st and 2nd classes. Each group can be put on or off by the passengers.

The L. T. E. is going to fit its new stock with 24″ long tubes. Auxiliary lighting consists of a few 50 V incandescent bulbs (fed from a battery), which can be used should the fluorescent lighting or the motor generator fail.

The Penna generally uses standard 220 V — 60 tubes in a continuous line along the centre of the coaches.

4. Measuring the intensity of the lighting.

Table III sums up the measurements of the intensity made by different Administrations.

TABLE

Administration	D. C. = direct current A. C. = alternatg. current	Voltage V	Fre-quency per/sec.	F. = fluorescent lighting I = incandescent lighting	*Carriages*	
					Source of power	Batteries
British Railways (B. R.)	D. C. — 	24 50 52	— —	I. I. I.	Shunt wound dynamo 20.5 kW full load 900 r. p. m. driven by axle, through trapez. belt between axle and gear box working the dynamo by cardan box.	Lead-acid 12 cells of 240 Ah at 10 hours charge.
Victorian Railways (V. R.)	D. C.	48 24	— —	I. I.	Shunt wound dynamo 20.5 kW full load 900 r. p. m. Trapez. belt between axle and gear box then cardan shaft between gear box and dy-namo.	Lead-acid 48 V 520 10 hours discharge.
New Zealand Railw. (Z. R.)	D. C.	24 6 120	— — —	I. I. I.	Shunt wound dynamo 65 A 24 V. Flat belt drive.	1st class, 5 batteries, capacity 400 Ah. 2nd class, 2 batteries capacity 200 Ah.
South African Railw. (S. A. R.)	D. C. A. C.	24 110 220	— — 60	I. I. and F. F. { 1st. cl. / 2nd cl. I. 3rd cl.	Shunt wound dynamo, dri-ven by flat belt when air conditioning is not fitted by cardan shaft and gears on other vehicles.	Lead-acid batteries of 300, 445 Ah. contin discharge 10 hours.
London Transport Executive (L. T. E.)	D. C. A. C.	600 50 24 110	— — — 850	I. I. I. F.	S Overground stock built before 1935 : direct feed 60 Underground stock built before 1935 : direct feed 60 Stock built since 1935 : 600 V motor generator 5 On stock hauled by steam or electric locomotives On stock under construction : motor generator.	
Pennsylvania Railroad	D. C. A. C. three phase	32 220	— 60	I. F.	Shunt wound dynamo with automatic field regulat and in the case of high power ratings by cardan s The alternating current is generated by a. c. alternat plied by the battery.	
Government of Indian Railways (I. R.)	D. C.	24	—	I.	Shunt wound dynamo with belt drive. 120, 100, 80	
Ceylon Government Railways (C. R.)	D. C.	24	—	I.	Shunt wound dynamo with belt drive.	
Sudan Railways.	D. C.	24	—	I.	Shunt wound dynamo with belt drive	

ng.

Motor coaches		Railcars	
Source of power	Batteries	Source of power	Batteries
:or-generator. - 52 V - 1 kW 2 500 r.p.m.)0 - 50 V - 1 kW.	Alcaline, nickel, cadmium. 36 cells of 125 Ah. at 5 hours discharge - 52 V. 34 cells of 125 Ah. 5 hours discharge - 50 V.	Shunt wound dynamo with field regulation. Trapez. belt on motor. 1.35 kW - 24 V.	
en from the overhead wire : 750 V. (6 lamps in series).	No batteries.	Dynamo 24 V.-50 A, driven from motor by trapez. belt. Cardan shaft and gears on the coaches.	Lead-acid. 24 V, 180 Ah. 10 hours discharge.
:or generator. 500 - 120 V.	Stand-by battery. Lead-acid 6 V 52 Ah. For one rear light, 2 lights in the coaches.	Shunt wound dynamo 24 V. Trapez. belt from the motor.	Lead-acid 185 Ah.
ary converter for the whole ke. \. 220 V. 60 per./sec.	No batteries.		
wer.	*Batteries*		
ird rail). l stand-by battery 12 V. :W and 50 V battery. dynamo and battery.	Lead-acid stand-by 12 V - 38 Ah. 10 hours discharge. Lead-acid 24 V, 150, 125, 100 Ah. 10 hours discharge. Lead-acid stand-by battery 50 V, 48, 56 Ah. 10 h. discharge on stock built since 1935.		
ven by flat or Trapez. belt, l gears; Powers 2 - 30 kW. motor current is sup-	Lead-acid and nickel-iron. Capacities of 300 - 1 250 Ah. - 32 V. 450 - 600 Ah. - 110 V.		
25 A.	Lead-acid batteries 300 - 270 - 210 - 150 - 100 Ah. Nickel-iron battery, nickel-cadmium battery : 300, 225, 150, 100 Ah.		
	Lead-acid, 2 sets of 12 cells.		
	Lead-acid 150 Ah.		

TABLE II. — Equ

Administration	Class of compartment	Coaches: Standard lighting Watts	Coaches: Reading lamps Watts	Coaches: Emergency lighting Watts	Electric rail motor coaches: Standard lighting Watts	Electric rail motor coaches: Reading lamps Watts	Electric rail motor coaches: Emerg lighti Wat
British Railways (B. R.)	1st class 3rd class 1st & 3rd cl.	2 × 15/ct ceiling 1 × 15ct/ ceiling 10 × 60 + 2 × 15.	4 × 15/ct above seats 4 × 15/ct above seats				
London Transport Executive (L. T. E.)	One cl. only 3rd class	22 to 30 × 60 W lights per coach 30 to 35 × 60 W lights per coach. 28 to 30 × 45 W lights per coach. 34 to 36 × 45 W lights per coach. 2 or 4 × 60 W lights per compartment. 4 × 20 compartment. 2 × 20 compartment.					
South African Railways (S. A. R.)	1st & 2nd cl. » 3rd class	6 × 25/ct 6 × 25/ct 2 or 3×25/ct			16 to 20 × 40/ coach. 16 to 20 × 30/ coach. 16 to 20 × 30/ coach.		
Victorian Railways (V. R.)	1st class 2nd class	1 × 75 1 × 75	6 × 15 8 × 15		trailing units : 36 × 46 motor units : 32 × 46		
New Zealand Railways (Z. R.)	1st class 2nd class cabin berth	24 × 15 14 × 20 2 × 8/ cabin 2 × 8/cabin	sleeping berths	2×8 cab.	26 × 40 W-120 V motor units. 28 × 40 W-120 V trailer units. No difference between classes. The lamps cannot be switched on by passengers.		
Ceylon Government Railways (C. R.)	1st & 2nd cl. 3rd class	Lamps of 25 W Lamps of 15 W					
Sudan Railways	Berth 1st & 2nd cl. 3rd cl.	2×15/ct 2×15/ct 1×15/ct		15/berth			

incandescent lighting.

Railcars			REMARKS
tandard lighting Watts	Reading lamps Watts	Emergency lighting Watts	
			Compartment coaches : the quantities given are per compartment in 1st and 3rd class, the 4 reading lamps can be switched out separately. In addition in 1st class compartments the 2 × 15 W ceiling lights can be dimmed. *Stock with centre corridor* : 10 × 60 W : from two ceiling lights along the corridor, and 2 × 15 W per compartment above each seat.
			Stock built before 1935 : underground stock and overground stock : lights on the ceiling and some behind the passengers. *Built between 1935 and 1938* : underground stock : in two rows along the ceiling. Overground stock : ditto. Electric compartment stock. Steam traction compartment stock : 1st class in front, 3rd class in front.
			Coaches : 6 × 25 in two groups 4 × 25 and 2 × 25. Each group can be lit up separately. *Rail motor coaches*: arranged in two rows along the coach, each row coming over the gap between the seats.
× 2 × 15 × 2 × 15	No mention of class.		*Coaches* : the 15 W reading lamps can be switched on or off separately by the passengers. *Rail motor coaches* : each 46 W — 116 V light is sited in a compartment 24″ from the centre line of the coach. *Railcars* : each group of 2 × 15 W lights is in a compartment 1′ 6″ from the centre of the coach.
× 2 × 20 er comp.	can be switched on by the passengers No difference between classes.	2 × 6 for the instrument nel at the driving compartment door.	*Coaches* : the passengers can switch the lights on or off. *Railcars* : the lights are in the ceiling above each row of seats.
			Coaches : 1st and 2nd class passengers can switch the lights on or off.

TABLE III. — Mea

Administration	Place or compartment	Coaches	
		Intensity ft. candles	Position of the light above the floor in ft. and inches
British Railways (B. R.)	general rule.	6.5 at 2′ 3″ from floor	ceiling
	3rd and 1st cl. at horizontal reading level.	5.75 to 7.5 at 3′ above floor.	ceiling
	3rd and 1st reading level at 45°.	6 to 6.8 at 3′ above floor.	ceiling
London Transport Executive (L. T. E.)	no difference between cl.		
South African Railways (S. A. R.)	1st and 2nd classes	12 — 15	ceiling
	3rd class	7	ceiling
	1st and 2nd classes	9	ceiling
	3rd class	7	ceiling
Victorian Railways (V. R.)	On the sides.		7′ — 4 3/4″ ceiling
	Under the lamp.		5′ — 2 1/2″ above the
	In the center of the coach.		shoulder of the passen
	General rule in 1st class.	10	
New Zealand Railways (Z. R.)	1st class	3	6′ 10″
	2nd class	a little less than above.	7′ 3″
Government of India Railways (I. R.)	1st class	4	Lights on the ceilir except the reading lamp
	2nd class	2	
	3rd class	1.5	
	Lavatories 1st and 2nd cl.	1.5	
	Lavatories 3rd class	1	

e lighting.

Rail motor coaches		Railcars		REMARKS
Intensity ft. candles	Position of the lights above the floor in ft. and in.	Intensity ft. candles	Position of the lights above the floor in ft and in.	
				Coaches with a centre corridor. Compartment coaches.
maximum 11 average 10 minimum 9	4′ 10″ minim. } underground stock built 6′ 5″ maxim. } before 1938. 6′ underground stock built in 1938. 6′ 2″ minim. } overground stock built 7′ 1″ maxim. } before 1935.			Underground stock : measurements made in 1945. On stock built in 1938 : intensity at reading level at 45° 3′ above the floor (sitting position).
9 6	ceiling ceiling			Coaches : main line stock (steam or electric locomotive). Rail motor coaches : the measurements are identical on trailing and motor units. Coaches : suburban stock.
7.5 15 13	7 3 1/2″	No measurements	6′ 4″	Coaches : measured at 2′ 6″ above the floor in the vertical plane through the lamp. Coaches : size and position of the reading lamp.
One cl. only 6	6′ 3″ and 7′ 3″	The diffusers were removed after the tests.	7′	Coaches : in the sleeping berths the lights are placed 1′ 6″ above the berth.
				Coaches : these intensities are the standard values to be obtained, they are checked on the coaches.

A few measurements have been made by the Penna on up to date stock with fluorescent lighting. An average intensity of 27.5 ft. candles was observed at reading level horizontally 33″ above the floor.

The measurements made by the Penna thus showed that for equal power, fluorescent lighting was about 2.75 times greater than incandescent lighting.

Fluorescent lighting therefore is a real factor in the comfort of passengers.

* * *

C. HEATING. VENTILATION.

Air conditioning, heat insulation.

a) *Steam heating.*

On the B. R. steam at a pressure of 30 to 80 lbs/sq. inch is distributed through the train by a main conduit. An auxiliary conduit branches off this main pipe, 1″ in diameter; this auxiliary conduit feeds the radiators. The radiators are thermostatically controlled. The steam conduits are sloped and fitted with steam traps to clear off any water due to condensation. It should be noted that the corridor radiators are housed in the body side casing.

The Z. R. use steam at 40 lbs/sq. inch in the main conduit. They use steam traps like the B. R.

The S. A. R. use steam to heat coaches equipped with air conditioning; the steam traps are fitted at the ends of the main conduit through each vehicle; the pressure varies from 70 lbs/sq. inch at the locomotive to 25 lbs/sq. inch approx. in the last coach.

The coaches of the Penna are fitted with air conditioning, and steam is used for heating.

This Railway uses main conduits 2 1/2″ in diameter, fed at 200 lbs/sq. inch; each coach is supplied from the main conduit through a branch pressure reducing valve reducing the pressure to 15 to 40 lbs/sq. inch according to the type of coach.

The corridors are heated by radiators against the corridor body side casings.

No Administration recovers the condensation water.

b) *Electric heating.*

The B. R. use radiators and footwarmers 2′ × 6″ × 1/16″. The footwarmers are made of woven material impregnated with plastic material. The voltages used are 230, 630 and 1 500 V. There are four 50 W footwarmers per compartment. A typical arrangement of heating radiators in a triple rail motor coach is as follows :

Driving compartment : 2 × 500 W i.e.	1 kW
2 guards vans : 2 × 500 W per van, i.e.	2 kW
Motor vehicle : 24 × 400 W i.e.	9.6 kW
2 trailer vehicles : 30 × 400 W = 12 kW per vehicle, i.e.	24 kW
	36.6 kW

Heating by means of footwarmers increases the temperature by about 30° F; it is only put into operation when the speed of the train exceeds 20 m. p. h. There are no corridor radiators.

The Z. R. use electric radiators connected in series and fed at 1 500 V.

Two series of 10 radiators, each 150 W, are arranged against the body sides in each unit. The total power is thus 30 kW per unit. The heating is based on the normal winter temperature, i.e. 32° F.

The S. A. R. fit 13 one kW radiators in series below the seats; these are supplied at 3 000 V. On vehicles fitted with air conditioning, the air is heated at 110 V and is based on a surrounding temperature of 40° F and a speed of 50 m. p. h.

The rail motor coaches used in suburban services on the Penna have electric heating at 600 V. The necessary power is taken from the main transformer fed at 11 000 V. The heating power is 9, 16.2, 25.4 kW per coach according to the temperature. These powers were based on the results of

winter trials. During these trials it was found that the effect of the speed is much less than the effects of opening the doors at frequent intervals.

The electric heating of the rail motor coaches of the L. T. E. is fed at 575 V from the 3rd rail. The powers used for the different types of stock are shown below :

Old overground stock : 6 kW/coach.

Old underground stock : 3 kW/coach.

Rail motor coaches and carriages divided into compartments : 6 to 8 kW/coach.

Modern overground stock : 4 kW/coach.

Modern underground stock: 3 kW/coach.

These powers have been decided by experience.

c) *Special systems of heating.*

The V. R. heat the motor units of their railcars with the engine cooling water; a copper pipe 1 1/2″ in diameter is fitted against each body side; this system of heating is brought into use and regulated manually. As it has only recently been put into service, it is not yet possible to state its advantages and disadvantages.

The Penna uses hot air heating for its light railcars and steam heating on its large railcars. The source of heat is respectively an anthracite stove and gasoil burners.

Main line coaches are equipped with steam heating. The radiators are arranged as in the large railcars. The Diesel-electric locomotives hauling these coaches are equipped with a steam generator plant.

The Z. R. heat their railcars by air blown in and using the heat in the engine cooling water. Thermostats control the working of the fans.

The heating can be regulated separately in each compartment. The temperature obtained is 65 to 70° F.

The Z. R. state that apart from the economy given by this system it has no special advantages.

The B. R. heat their old types of railcars by the engine cooling water. These railcars are now used on branch lines where there are frequent stops, which reduces the power available for heating.

The recent multiple unit railcars have a steam generator with gas-oil burner, which is much more effective than the system of heating by the cooling water. The steam generator is sufficiently powerful to heat the 3 units of a multiple unit railcar.

d) *Regulating the heating.*

The B. R. have thermostats in the radiators on coaches heated by steam; these thermostats cut the steam off at a given temperature and the control of this temperature takes place in each compartment.

The rail motor coaches have a central switch enabling the conductor to operate the heating system. A thermostat placed in the motor units controls the temperature therein as well as that of the trailing units.

The train staff put the heating system on in the railcars. The staff and the passengers can regulate it.

The passengers regulate the heating in the Z. R. coaches heated by steam by hand.

The control of the heating in the rail motor coaches is by thermostat; the average temperature is 68° F, the variation about 4° F.

On the railcars with heating by the cooling water, the heating is regulated by thermostats working the fans which force the air to be heated through hot water radiators. The temperature can be regulated in each compartment between 65-70° F with variation of 5° F in the temperature.

The S. A. R. allow the passengers to regulate the heat in each compartment of coaches heated by steam radiators.

The temperature of the rail motor coaches is regulated by thermostats; the average temperature is 75° F with variations of about 12° F.

The L. T. E. make the train staff responsible for regulating the temperature. In the case of steam trains the guard advises the driver if the steam pressure should be

diminished or increased, according to the readings of a thermometer. The temperature is maintained at about 55° F.

The same method is used on the rail motor coaches; the guard operates the main heating contact.

e) *Ventilation.*

On recent stock forced ventilation is part of air conditioning, and will be dealt with under *f*) below. On older stock, generally ventilation is assured by taking in air on the roof of vehicles or by ducts in the body side panels; the flow of air through these openings is not regulated, but in the case of ducts it can be controlled by a shutter.

f) *Air conditioning.*

The characteristics of the air conditioning systems in use are given in Table IV. One conclusion to be drawn from this table is that in all the systems using cooling of the ventilation air, double fixed windows have been fitted in the body sides.

The energy required for the different systems is generated by dynamos driven by the axles, batteries providing the necessary power when the train is standing. The power varies between 18 and 25 kW.

g) *Heat insulation.*

The V. R. have provided the following heat insulation along the body sides, roofs and partitions of coaches :

1 layer 1/32″ « Turnall », 4 layers 0.0003 « Alfol »;

1 layer 1/32″ « Turnall », 1 layer of 3/4″ felt stuck on the roof and the outer sheeting.

The insulation of the flooring is as follows :

1/8″ rubber carpet, 3/16″ sponge rubber, 1/38″ « Anka » cardboard, 1 1/4″ cork sheets.

The Keystone floor consists of :

7/8″ air space, 3/4″ felt stuck to aluminium sheeting.

The roofs of railcars are covered with two layers of « Tropal » (kapok mattress) 1″ thick (fireproofed), with 1″ air space between the two. The coefficient of transmission is 0.23 B. T. U. per 1″ per foot, per 0° F per hour.

The roofs of the rail motor coaches are made of « Masonite ».

The Penna uses glass fibre as a fireproof and odourless thermal insulator. The body-sides, floor and ceiling are covered with 3″ of insulating material and the walls with 2″. This insulates against both heat and sound. The coefficient of transmission of the glass wool is about 0.25 B. T. U. per foot, 0° F, per 1″ thickness.

The Z. R. have 5/8″ thick asbestos compound covering the sheeting and a thicker layer covering the roofs. There are two layers of 7/8″ « Tentest » bitumastic solution between the floor and the floor supports.

* * *

D. INTERIOR DECORATION.

1. Seats.

Figs. 1 to 24*b* show the different arrangements adopted for the seating.

a) **British Railways (B. R.).**

I. — *Coaches.*

Figs. 1, 2 and 3 show side corridor 1st and 3rd class coaches and 1/3 composite coaches respectively.

The 3 division seats with arm-rests for each seat are of the compartment type; their framework is of steel and wood. The seats and backs are upholstered with conical springs and horsehair between calico. The head-rests are stuffed with hair. Moquette is generally used as the covering.

Figs. 4 and 5 show diagrams of 1st and 3rd class central corridor coaches. There are 3 seats aside in the 1st class and 4 in the 3rd class. The upholstery of the seats and backs is made of conical springs and

horsehair and wadding. The arm-rests are covered with sponge rubber. In 3rd class compartments the seats are upholstered with conical springs, horsehair and felt, and the arm-rests with padded horsehair.

II. — *Railcars.*

Fig. 6 shows diagramatically a single class 48 seater railcar.

III. — *Rail motor coaches.*

Figs. 7*a*, *b*, and *c*, show the interior arrangement of a triple unit rail motor coach : 7*a*, motor van, 7*b* coach, and 7*c* coach with driving compartment.

b) **New Zealand Railways (N. Z. R.).**

I. — *Coaches.*

Figs. 8*a* and 8*b* show the arrangement of the new 1st class coaches. There are three seats across the compartment in each case. The seats are reversible, and the slope of the backs can be adjusted by the passenger. The backs have a lateral support and head-rests; arm-rests and foot-rests are provided. The seats are covered with sponge rubber, the backs upholstered with horsehair embedded in rubber. The covers are of leather. In Fig. 8*a* it should be noted that one of the lavatories is reserved « ladies only ».

Fig. 9 shows one of the new 2nd class coaches. There are 4 seats across, and the double seats can be reversed but the slope of the backs is fixed. There is an arm-rest only on the corridor side; there are no lateral supports nor head-rests on the back. The upholstery is identical with that of the 1st class seats. Here again there is a « Ladies only » lavatory.

Fig. 10 shows a composite 1/2nd class coach. In each class the arrangement is the same as in those described above.

II. — *Railcars.*

Figs. 11*a* and 11*b* show a mixed 1/2nd class railcar and a 2nd class railcar of the same length (66′).

In the 1st and 2nd classes, the seats pivot and the backs can be adjusted by the passengers. There are individual seats in the 1st class and double seats in the 2nd class cars. The seats, backs and arm-rests are covered with sponge rubber and leather.

Fig. 12 shows a 47 1/2′ long 2nd class railcar. This railcar is carried on a bogie and a carrying pair of wheels. There is only one driving compartment, and the car always runs with the driving compartment at the front end.

III. — *Rail motor coaches.*

Figs. 13*a* and 13*b* show respectively a 2nd class motor van with two driving compartments and a 2nd class trailer. The seats are pivoting. The upholstery of the backs and seats is in sponge rubber with a leather covering.

It should be noted that no lavatories are provided in the 2 vehicles just described.

By the doors the seats are arranged against the body sides, to make room for standing passengers near the entrance or exit.

c) **Ceylon Government Railways (C. G. R.)**

Figs. 14, 15 and 16 show respectively the 1st, 2nd and 3rd class centre corridor coaches. The upholstery of the seats and backs is carried out with conical spring and padding, either in horsehair or sponge rubber. The covers are moquette or Rexine Vynide imitation leather. There are two W.Cs. for each class.

Figs. 17 and 18 show side corridor 1st and 2nd class sleeping berth coaches. The backs of the seats can be pulled out to form the upper berth. There is a wash-bowl in each compartment.

There are 3 lavatories for the 1st class coach.

d) **Victorian Railways (V. R.)**

I. — *Coaches.*

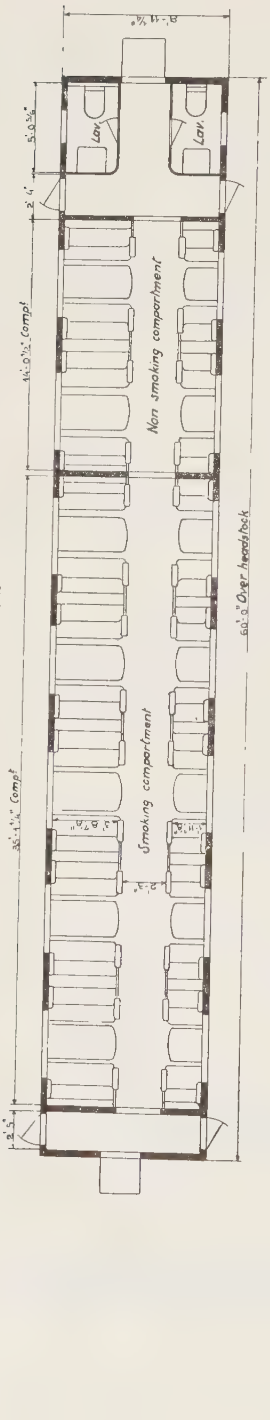
Figs. 19 and 20 show recent main line 1st and 2nd class coaches with side cor-

TABLE

Administration	Cooling capacity	Heating capacity	Output of air for ventilation	Sun temper scaled
British Railways (B. R.) « Thermotank » system	The temperature is regulated by mixing hot air with the ventilation air which is not cooled. It can be regulated by the passenger above each berth.	The air to be heated is forced by a fan through a filter below a steam heater.	The ventilation air is forced by a fan through a filter.	
« Stone » system	The atmospheric air is forced through a filter by a fan. After passing through the filters, the total output of air is divided into two parts, one of which passes over steam radiators, and is then mixed with the other part.			Controlle the shutt into two
Royal Train	Cooling by means of ice. Thermostat control.	The ventilation air is heated by steam radiators. Electric heating in addition. Thermostat control.	Not mentioned.	from 74 from 3 to
New Zealand Railways (Z. R.)	No cooling.	Controlled by liquid thermostats (capsules).	Output 2 000 c. f. m. forced through filters, air renewed every 2 minutes.	Kept low quick chan and insul
South African Railways (S. A. R.)	5 tons (for a temperature of evaporation of 42° F and condensation of 135° F regulated by thermostat within 2 degrees).	4 000 watt heating elements regulated by thermostat within 2 degrees.	Circulating fresh air 40 % of the total air circulation.	Outside above 100 90 80 75 Night.
Pennsylvania Railroad (PENNA)	8 tons, 4 cylinder compressor, 12 HP motor.	Heating element for fresh air 120 000 BTU per hour.	Total output 2 400 c. f. m. of which 33 % i. e. 800 c. f. m. is fresh air and 1 600 c. f. m. recovered air. Power of the fan 1 HP.	No 74
Victorian Railways (V. R.)	7 tons.	To heat air 4.5 kW. Compartment 0.25 kW. Total (8 compartments)	Conditioned air 1900/2000 c. f. m. Recovered air 1200/1400 c. f. m. Fresh air 500/700 c. f. m.	An inside ity is m reaches 95
India Railways (I. R.)	5 1/2 tons (66 000 BThU/hr.) « Freon » refrigerator. Old systems use ice.	The climate of India makes heating unnecessary.	Characteristics not given.	Dry therm outsi 11 10 90 90 80

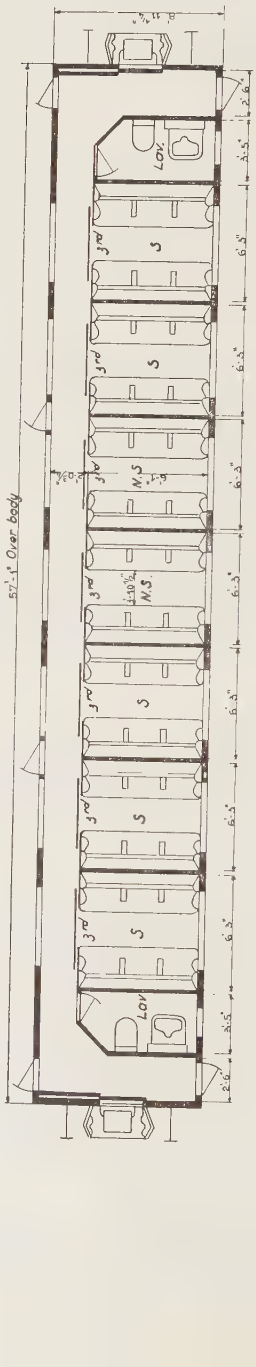
itio ing.

ıe equipment					
degrees of humidity			Kinds of windows	Power, source of power	REMARKS
Winter temperature scaled 0° F	Wet therm. 0° F	Dry therm. 0° F			
nentioned.			Operated by the train staff.	Not mentioned.	There is no cooling of the air with this system. The temperature can be lowered by mixing ventilation air with the hot air. Installed in sleeping cars — 1st class.
stats acting on ides the air flow			Operated by the train staff.	Not mentioned.	There is no cooling with this system. The temperature is lowered by mixing hot and ordinary air in different proportions. Fitted to 36 restaurant and buffet cars.
om 55° - 75° F scales of 5° F	No control.		Can be worked by the train staff. Double windows	A separate vehicle supplies the power.	
ept at 65 - 70° F	No control.		One third of the windows open, two thirds are fixed.	Power taken from the lighting dynamo and batteries.	Only installed on coaches.
utside bove / Inside the coach 70 / 68 60 / 68 50 / 66 40 / 64 30 / 64 light / 64	75 95 between 35° and 65° relative humidity.		Double fixed windows.	Shunt dynamo driven by trapez belt, gears and cardan shaft. Battery Exide Ironclad 390 Ah. at stop.	
70	69.5° 82° inside. 80° 100° outside for 80 passengers		Double fixed windows.	25 kW dynamo driven from an axle and batteries.	Fitted on all main line coaches.
e of 70-75° F with 50 % humid- en the outside temperature % humidity.			Double fixed windows (can be removed for cleaning).	Dynamo driven from an axle and batteries.	Installed on the new coaches.
utside humidity 25 % 50 % 80 % 70 % 90 %	Dry therm. ins. the coach 85 82 78 78 75		Fixed windows.	18 kW dynamo driven from an axle by trapez. belt. Full charging at 23 m. p. h. Accumulators: lead-acid 780 Ah.	



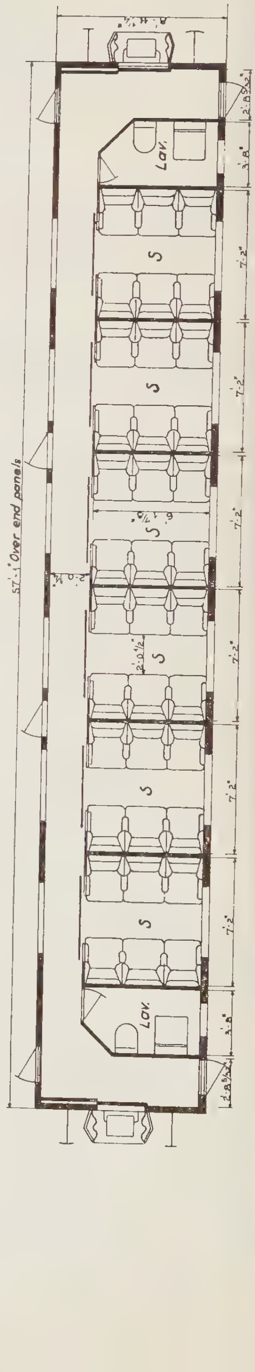
B.R.
FIRST CLASS VESTIBULE CARRIAGE
42 seats

Fig 4



B.R.
CORRIDOR THIRD
42 seats

Fig. 2



B.R.
CORRIDOR FIRST
36 seats

Fig. 1

Fig. 6.

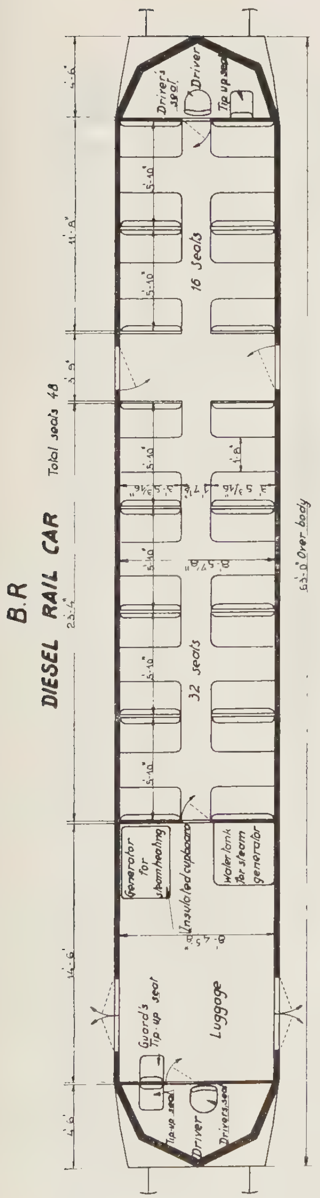


Fig. 3

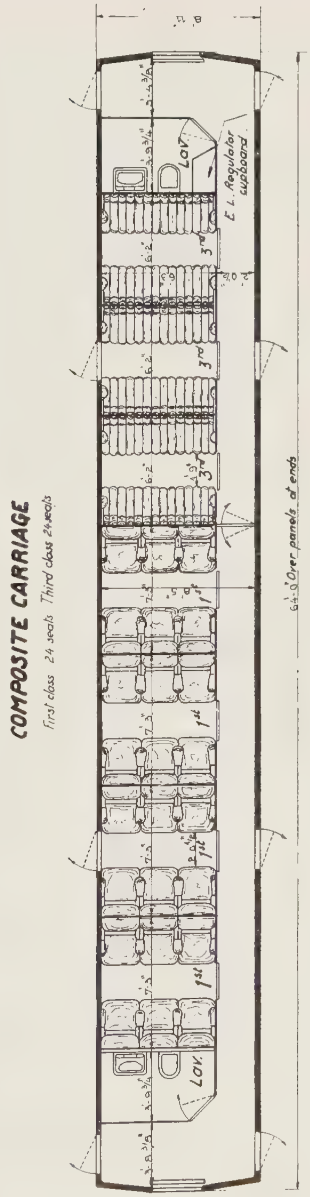
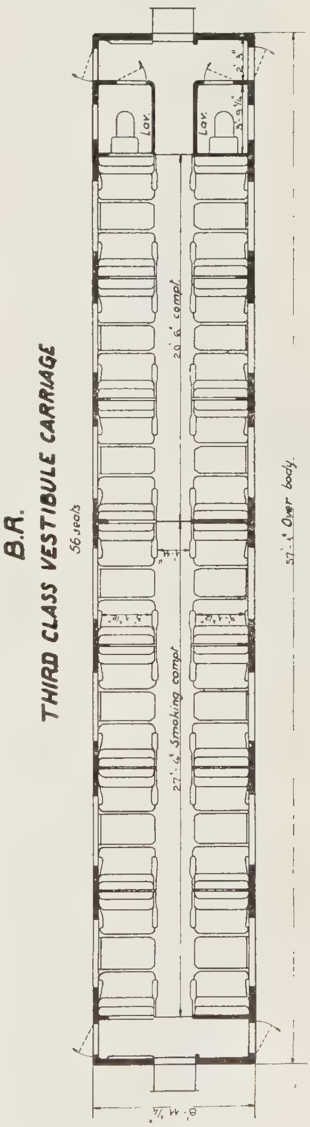


Fig. 5



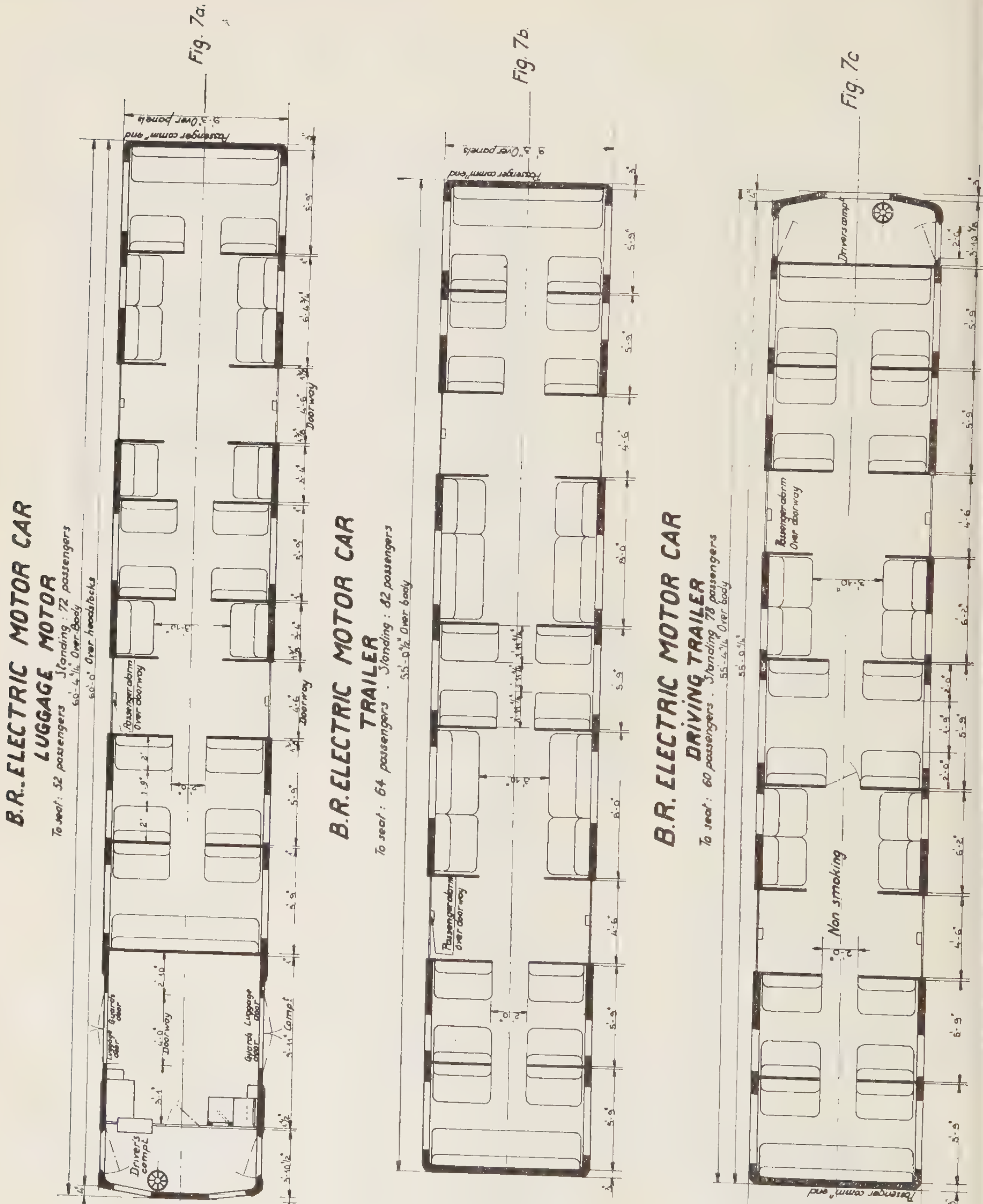


Fig. 7a.

Fig. 7b.

Fig. 7c.

Fig. 8a

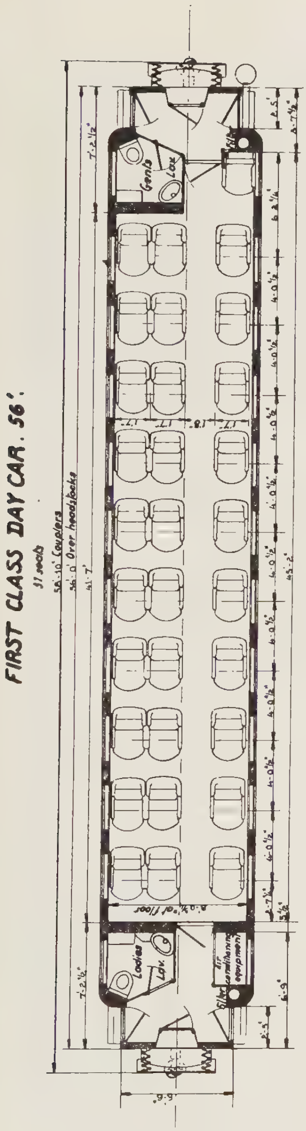


Fig. 8b

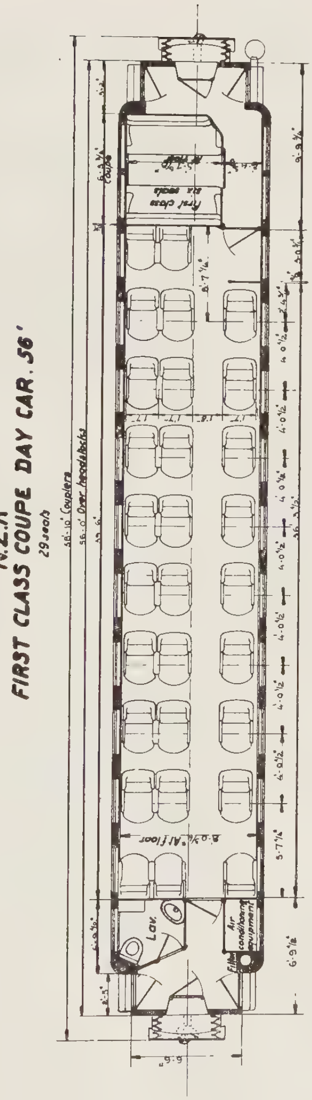


Fig. 11a

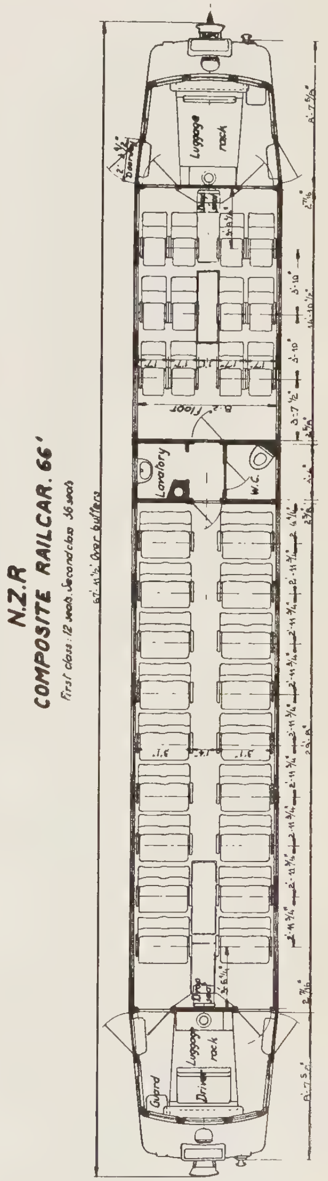
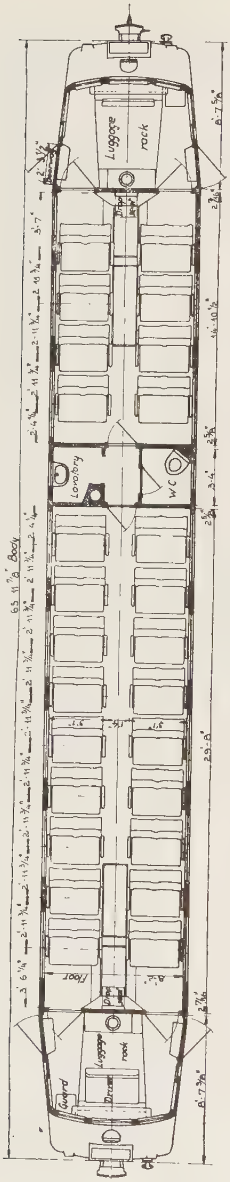
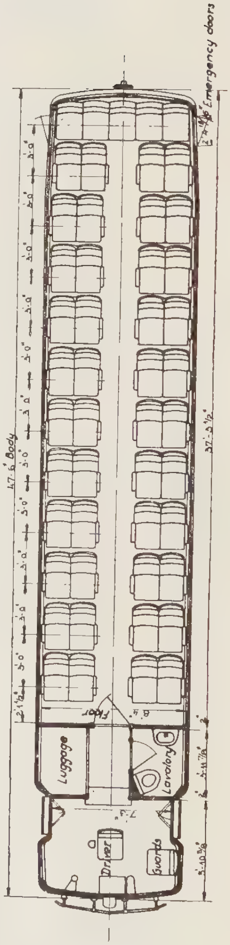


Fig. 11b



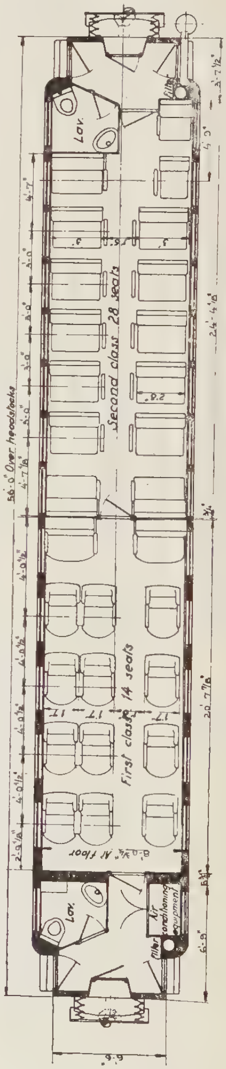
N.Z.R.
SECOND CLASS RAILCAR 66'
52 seats

Fig. 12



N.Z.R.
SECOND CLASS RAILCAR
49 seats

Fig. 10



N.Z.R.
COMPOSITE DAY CAR. 56'
First class 14 seats. Second class 28 seats

ridors. The upholstery of the seats and backs is with conical springs and padding with horsehair combined with rubber. The covers are of leather.

II. — *Railcars.*

Figs. 21, 22 are diagrams showing the interior arrangement of composite large and small railcars respectively.

The upholstery of the seats and backs is in sponge rubber covered with leather.

e) **South African Railways (S. A. R.).**

I. — *Coaches.*

Fig. 23 shows a recent 1st class sleeping berth car for main line service, and a 1st class coach respectively. The upholstery of the seats is done with springs and the padding with horsehair. The cover is in leather. The backs of the seats can be pulled up to form a berth.

II. — *Rail motor coaches.*

Figures 24*a* and 24*b* show diagrams of a 1st class rail motor coach and a 1st class coach. The upholstery of the seats is with springs and padding with horse hair. The cover is in leather. The 2nd class compartments are 5′ 10″ and the 3rd class compartments 4′ 11″. In the 3rd class, corridor is 1′ 4 3/4″ wide and the seats are 4′ 1 1/2″ and 2′ 7 1/2″ wide respectively.

f) **Pennsylvania Railroad Co. (Penna).**

The Penna has two standard types of double seats : seats with reversible backs and pivoting seats with backs adjustable by the passenger. All the new coaches have seats upholstered in sponge rubber. The seats are covered with mohair, the backs with carpet. The general arrangement is 4 seats across in pairs forming a double bench. The central corridor is 2′ 1 3/4″ wide, and that of the restaurant cars a minimum of 2′. The seats are 2′ 11 1/2″ long in the case of the large capacity vehicles with reversible seats, and 3′ 5 1/2″ long in vehicles fitted with pivoting seats with adjustable backs; the latter measurement has been increased to 3′ 8″ on recent stock.

g) **Indian Government Railways (I.R.)**

The seats used by this Administration are made of wood in the 3rd class and are upholstered with springs and horsehair in the 1st and 2nd class carriages. They are covered with imitation leather.

The width of the corridors is 1′ 7 1/4″ in 3rd class, 1′ 9″ in 2nd class and 2′ in first class. The depth of the seats varies from 1′ 6″ in 3rd, to 2″ in 2nd and 1st class; there is a space of 1′ 7 1/2″ between opposite seats in 3rd class and 2′ 2″ in 1st and 2nd class.

2. *Interior wall and floor covering — Interior fittings. Arrangement of W. C.*

a) **British Railways (B. R.).**

The interior lining of the walls is usually plywood on which Rexine or Formica is stuck in some cases; a few coaches have been finished with leather. The floors are covered with linoleum, with carpets in the 1st class carriages. The dimensions of the luggage racks in compartment coaches is 5′ 6 1/2″ × 13″. There are no special carriages for children; on the suburban and long distance night trains a few compartments are reserved « ladies only ». The fittings for the use of passengers in the 1st class carriages are : coat-hooks, curtains, mirror, shelves, ashtrays; the same fittings are provided in the 3rd class carriages, but blinds are fitted instead of curtains.

The arrangement of the W. C. is practically identical in 1st and 3rd class; there is a washbasin, with hot water in winter, a radiator and a mirror. The walls are covered with painted plywood or with plastic material. Most of the floors are made of « Terrazzo » with central drain to keep them dry. The tanks hold 50 to 60 gallons. Since the war toilet paper has only been provided on main line trains. Towels and soap are provided however in the case of sleeping cars.

Fig. 13a

N.Z.R.
ELECTRIC MOTOR COACH
Second class. 60 seats

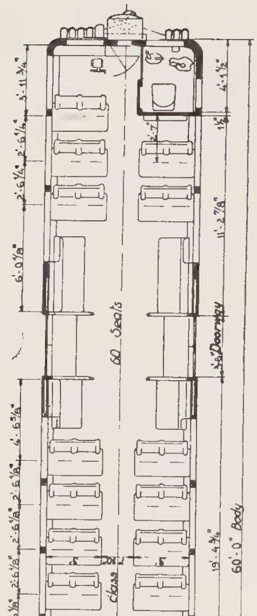


Fig. 13b

N.Z.R.
DRIVING TRAILER COACH
Second class. 72 seats

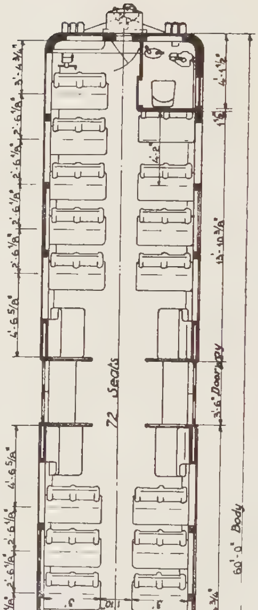


Fig. 9

N.Z.R.
SECOND CLASS DAY CAR
Second class. 56 seats

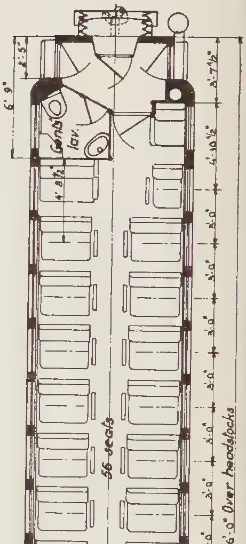
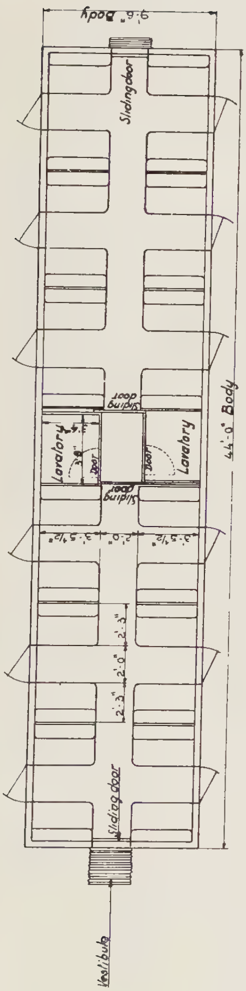


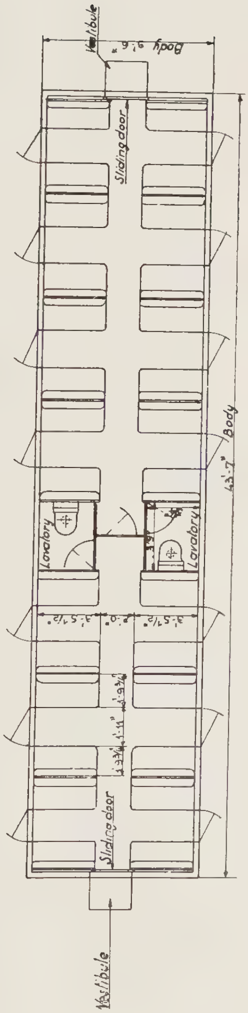
Fig. 14



CORRIDOR FIRST CLASS CARRIAGE
48 passengers

Note. Equipped with fittings to take portable refreshment tables

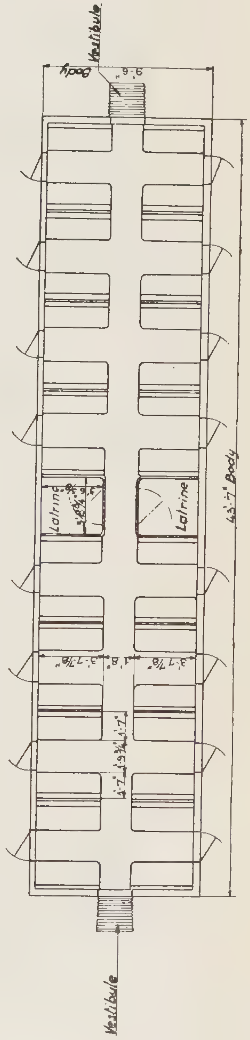
Fig. 15



C.G.R.
CORRIDOR SECOND CLASS CARRIAGE
56 passengers

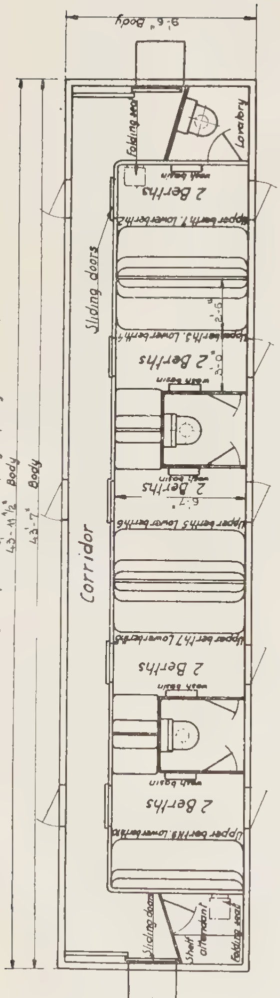
Note. Equipped with fittings to take portable refreshment tables

Fig. 16.



C.G.R.
CORRIDOR THIRD CLASS CARRIAGE
96 passengers

Fig. 17.

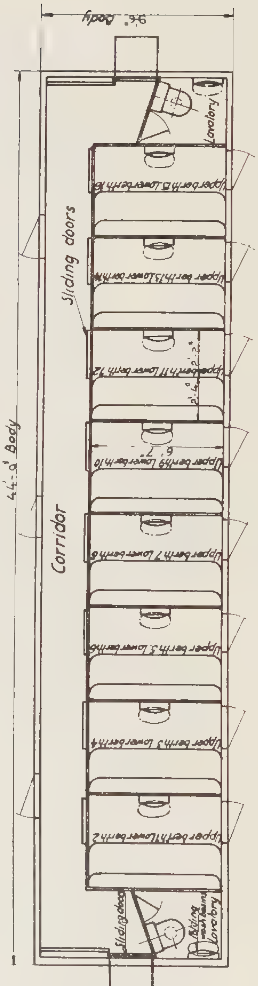


C.G.R

CORRIDOR FIRST CLASS (CONVERTIBLE)

Seating capacity: 15 passengers. Sleeping capacity: 10 berths

Fig. 18

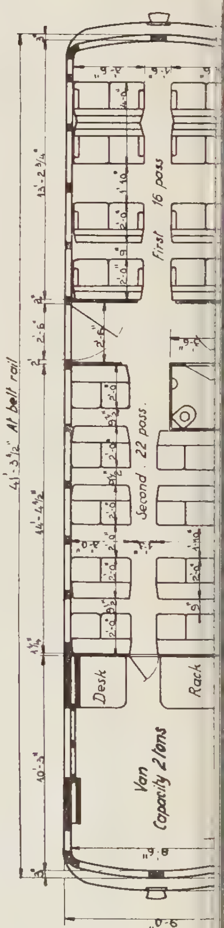


C.G.R

CORRIDOR SECOND CLASS (CONVERTIBLE)

Seating capacity. 32 passengers Sleeping capacity: 16 berths

Fig. 22



VICTORIAN RAILWAYS

COMPOSITE RAILCAR.

first class: 16 pass. Second class: 22 pass.

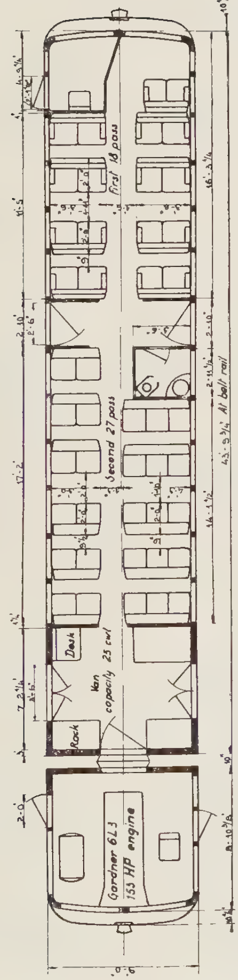


Fig 21

VICTORIAN RAILWAYS
COMPOSITE RAILCAR
First class 18 pass Second class 27 pass

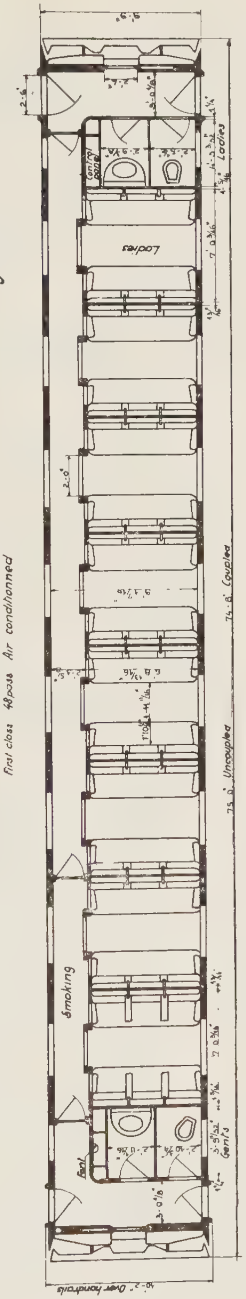


Fig. 19

VICTORIAN RAILWAYS
First class 48 pass Air conditioned

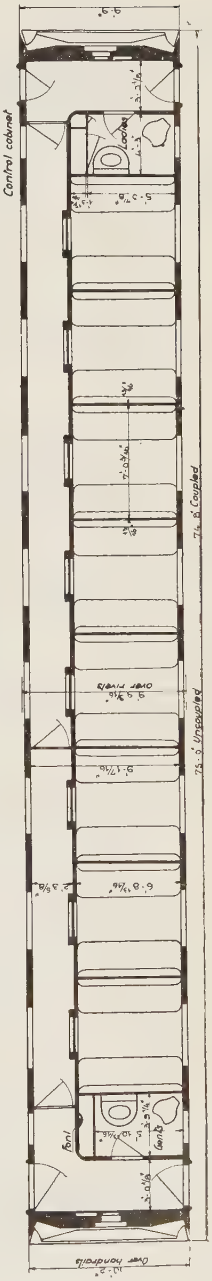


Fig. 20

VICTORIAN RAILWAYS
Second class 64 pass

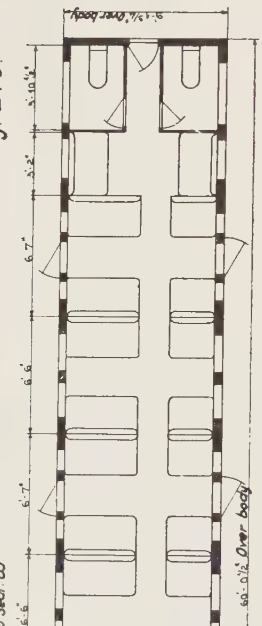


Fig. 24 b.

S.A.R
FIRST CLASS TRAILER
To seat 83

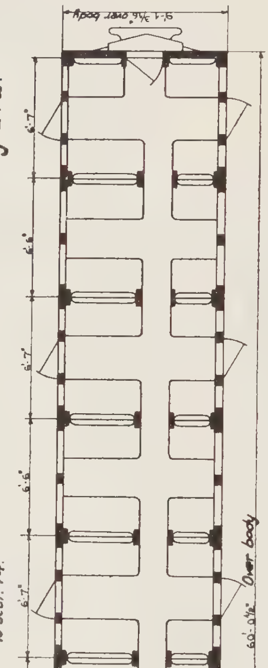


Fig. 24 a.

S.A.R.
MOTOR CAR. FIRST CLASS
To seat 74.

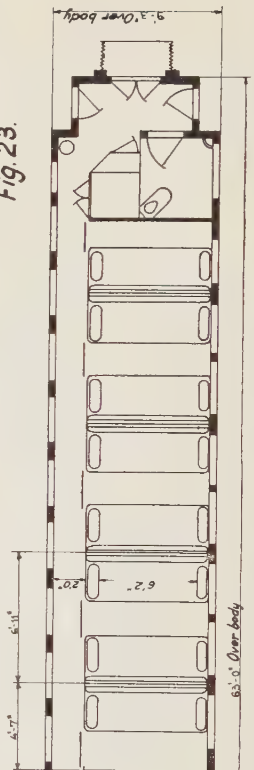


Fig. 23.

S.A.R.
FIRST CLASS TRAILER
To sleep 26. To seat 39

Soap solutions are used to clean the walls and ceiling. « Terrazzo » floors are cleaned with Cresol, and the metalwork is polished dry. The actual lavatory pan is cleaned with spirits of salt.

b) New Zealand Railways.

The inside walls are covered with plywood or « Sundeala » covered with Rexine. In line with the floor and luggage racks there is a covering of rubber all round.

The floor is covered with linoleum or rubber. The dimensions of the luggage racks are: 11 1/2″ or 9 1/2″ deep on the coaches, 15 1/2″ or 13″ on rail motor coaches, 12 1/2″ or 11 1/2″ on railcars. There are no « Ladies only », but when there are two lavatories, one is reserved for ladies. The fittings provided are: coat-hooks, blinds, ashtrays, mirrors and wastepaper baskets in the W. C. It should be noted that there are no W. C. s on the rail motor coaches.

The W. C. walls in 1st class carriages and railcars are lined with plywood covered with plastic material or Rexine; in 2nd class carriages use is made of plywood covered with metal sheeting.

The floor is covered with rubber, which is sometimes carried up 10″ on the walls. The total capacity of the tanks in 1st class carriages is 140 gallons; it is 176 gallons in the 2nd class carriages; the tanks on the railcars hold 50 gallons.

The water for the washbasins is only heated in the case of 1st class carriages on the night expresses all the time, and during the winter on the day expresses. Soap, towels and toilet paper are provided in all W. C. s.

The W. C. s. are cleaned with a soap solution to which some disinfectant is added.

c) Victorian Railways.

The inside walls of the railcars and rail motor coaches are of masonite; those of carriages in plywood.

The floors of railcars are covered with 1/4″ of rubber laid on 1/4″ of cork; those of rail motor coaches are covered with linoleum; those of carriages with 1/4″ of rubber on 3/16″ of sponge rubber, with a carpet on top.

The dimensions of the luggage racks are:

1) *coaches:* width 1′ 3/4″ by 6′ 8″ along the wall;

2) *railcars:* width 15″: total length in motor units: 54′ and in trailer units 47′. Space under the seats: height 9 1/2″ width 2′ 9″ in the case of double seats and 4′ 3″ for 3 seats;

3) *rail motor coaches:* width 12″, total length 72′ in the case of motor units and 76′ in trailer units.

In each first and 2nd class coach there is one compartment reserved for women and children. The fittings provided in the carriages are: blinds, shelves, ashtrays, reading lamps.

The W. C. walls are covered with masonite on the railcars and with « Zincanneal » sheets painted half way up and painted plywood above in the coaches.

The floors in railcars are covered with rubber, and with « Terrazzo » in the coaches. Water is distributed under pressure; the capacity of the railcar tanks is 50 gallons, and that of the coach tanks 140 gallons.

Soap, towels and toilet paper are provided in all lavatories. There is a centre drain to keep the floors dry. The lavatories are cleaned with a soap solution to which phenol disinfectant has been added.

d) Pennsylvania Railroad Co. (Penna.).

The floor is covered with 9″ by 9″ stuck on asphalte blocks. In the compartments there are blocks covered with carpet.

The luggage racks are 18″ wide, and for heavy luggage two cupboards 24″ high, 2′ 6″ deep and 2′ 9″ wide are provided at

TABLE V. — **Characteristics of the flexible**

Administration and types of stock	Type of sus-pension	Steel use — Laminated springs — Chemical composition % C	Mn	Si	Cr	S	P	Heat treatment	Stres allov und static
British Railways	1	0.45 0.55	0.80	—	—	0.05	0.05	Water hardened and tempered.	30 to sq. 47 to 6 mm
London Transport Executive L. T. E.	1	0.50/ 0.65	0.70/ 1.00	1.50/ 2.00	—	0.05	0.05	Maximum temperature 950°. Oil hardened from 800°-850° C. Tempered at 500 - 550°C.	Motor tare loade Other tare loaded t/sq.
Pennsylvania Railroad Company	3	0.90/ 1.05	0.30/ 0.50	0.15/ 0.30	—	0.05	0.04	Reheated after forming at high enough temperature to obtain a fine grain. Oil tempered to cool at 300° C.	75 0 lbs./sq
Government of India Railways	1 normal gauge	0.33/ 0.48 0.48/ 0.54	0.85/ 1.00 0.85/ 1.00	1.60/ 2.00 1.80/ 2.00	—	0.05	0.05	Water hardened Oil hardened } Specif M11 - 48	30 t/sq
	4 m. gauge	To be submitted by the supplier.						Specific. M 10-49	
South African Railways	2 railcars 4 coaches	As proposed by supplier.						Water hardened. Heated to 840°C. Tempered at between 750° to 790° C. Reheated 400 - 450° C. Specification C. M. E. 6/1949.	55 kg/
Victorian Railways I. Coaches.	5	0.47/ 0.56	0.55/ 0.70	1.20/ 1.60	0.60/ 0.80	0.05	0.05	Heated to 830-880° to get a fine grain. Oil tempered 800° C. (oil tempered 15 - 60° C). Reheated 450 - 550° C.	80 kg/
II. Railcars. Trailers. III. Motor coaches	4	Composition unknown. Brinell hardness 228 (ball 10 mm, load 3 000 kg)						Treatment unknown. To get a fine grain 800 - 850° C. Water hardened from 750 - 800° C (water hardened 15 - 40° C). Reheated 400 - 500° C.	46 kg/ motor 47.5 kg trailer 57.5 kg
New Zealand Railways I. Coaches. II. Railcars. III. Motor coaches	2 — 3	British Standard Specification. Rep. 24. Part 3/6B1942. British Standard Specification. Rep. 24. Part 3/6B/1942. British Standard Specification. Rep. 24. Part 3/6/1932.							
Sudan Railways	1	Silico-Manganese Steel, Oil hardened. British Standard Specifications, Report 24. Part 6y.							

of the suspension gear.

he springs								
Coiled springs								Rubber stresses allowed
Chemical composition %						Heat treatment	Stresses allowed under static load	
C	Mn	Si	Cr	S	P			
.90	0.45/0.70	0.30	—	0.05	0.05	Oil hardened and tempered.	34 t/sq. in 53 kg/mm^2	0.07 to 0.10 t/sq. in
/0.63	0.70/1.00	1.70/2.00	—	0.05	0.05	Max. temperature 950° C. Oil hardened from 800 - 850° C. Tempered at 450 - 500° C.	Motor axles tare 30, load 41. Other axles tare 22, load 31 t/sq. in.	
As for laminated springs.								
/1.20	0.45/0.70	0.30	—	0.05	0.05	Specif. M24 - 49.	30 t/sq. in	
/0.60	0.70/1.00	1.50/2.00	—	0.05	0.05	Specif. M25 - 49.		
/1.15	0.75/0.45	0.30	—	0.05	0.05	Oil hardened : heated to 830° C, Tempered at between 750 - 780° C. Reheated 450 - 500° C. Specification C. M. E. 7/1945.	39 kg/mm^2	0.123 kg/mm^2
Same composition as for laminated springs.						Oil hardened at 820° C. Reheated 450 - 475° C.	43 kg/mm^2	
Composition unknown.						Treatment unknown.	35 kg/mm^2	
/1.05	0.60/0.80	—	—	0.05	0.05	Oil hardened 800° C. Reheated 450 - 475° C.	Motor coach. 35 kg/mm^2 Trailer 44.6 kg/mm^2	
sh Standard Specification. Report 24. Part 3/7C/1942. sh Standard Specification. Report 24, Part 3/7C/1942. sh Standard Specification. Report 24, Part 7/32.								Rubber on the centre and side links
o-Manganese Steel, oil hardened. sh Standard Specifications, Report 24. Part 7y.								

TABLE VI. — **Characterist**

Administration and type of stock	Flexibility of the suspension		Weight		
			suspended		non susper
	primary suspension	secondary suspension	body	bogies (possibly motor)	axles and axle b
British Railways 57′ coach	7.66 t/in. = 306.4 kg/mm	9.92 t/in. = 396.8 kg/mm	20 t = 20 320 kg	4 t = 4 064 kg	6 t = 6 09
London Transport Executive					
Underground stock	mot. axle 9.5 mm/t other 12 mm/t	5.7 mm/t	7.8 t	3.76 t	—
Overground stock	mot. axle 10.85 mm/t other 12.65 mm/t	3.4 mm/t	8.3 t	4.66 t	—
Pennsylvania Railroad Company	3.69 in.	7.30 in.	—	—	—
Government of India Railways Standard gauge stock.	1/8 in/t	5/32 in/t	38 t	16 t	—
South African Railways					
Coaches of blue train . . .	69 mm 38.8 t = 1.78 mm/t	82 mm 36.2 t = 2.26 mm/t	36.20 t	2.20 t	—
Rail motor coaches :					
Motor unit	1.15 mm/t	2 mm/t	44.6 t	7.4 t	—
Trailing unit	2.2 mm/t	3.6 mm/t	25.44 t	1.12 t	—
Victorian Railways					
I. Coaches	2.1 mm/t	4.45 mm/t	38.48 t	5.04 t	—
II. Railcars : Trailer . . .	5.5 mm/t	inexistant	body + bogies : 17.36 t		—
III. Rail motor coach :					
Motor bogie	1.48 mm/t	2.92 mm/t	34.12 t	11.08 t	—
Carrying bogie	1.77 mm/t	5.95 mm/t	25.80 t	5.08 t	—
New Zealand Railway					
I. Coaches	3.26 mm/t	3.22 mm/t	25.6 t aver.	3.65 t	—
II. Railcars	2.86 mm/t	1.6 mm/t	17.84 t	4.80 t aver.	—
III. Rail motor coach					
Motor bogie	total : 5.1 mm/t		—	—	—
Carrying bogie	total : 6.35 mm/t		—	—	—
Sudan Railways.	4.1 mm/t	0.61 mm/t	26 t	0.8 t	—

ty and play of the suspension gear.

Bolster				Axle boxes		Hydraulic or friction shock absorbers
Links		Play		Maximum play		
length	inclination	lateral/2	longitudinal	lateral	longitudinal	
1′ 13/16″	± 1 1/2″	3/4″ — 2 3/4″	1/32″ — 1/16″	3/64″ — 1/8″	3/64″ — 1/8″	No
—	± 1 1/2″	1″ — 1 1/4″	1/32″	1/32″ — 7/64″	1/32″ — 7/64″	No
11 15/16″	7° 12″	2 1/4″	Movement limited by arm with rubber bearing.	1/4″	1/16″	No
—	10°	1 1/2″	—	—	—	No
1′ 2″	—	2 1/4″	—	Undetermined	—	No
6 5/8″	—	1 3/8″	—	Undetermined	—	No
′ 3/14″	—	1′ 7/8″	—	Undetermined	—	No
6 3/4″	6° 7′	2″	1/8″ — 3/16″	7/32″	—	No
—	—	—	—	Undetermined	—	No
3 7/8″	7° 14′	1 5/16″ — 2 3/32″	1/32″ — 3/16″	1/4″	—	No
2 3/8″	1 11/16″ — 6.5°	1″	—	1/16″ — 3/16″	—	No
7 21/32″	3 1/2″	1 1/2″	1/16″	1/16″ — 3/16″	—	hydr. shock abs
3 3/4″	2 1/2″	1 1/4″	1/16″	1/16″ — 3/16″	—	No
2 1/8”	2 1/4”	1”	—	1/16”	—	No low-speeds non ballasted track

the end of each coach. The fittings provided are: blinds, mirrors, ashtrays, cardboard cups in conjunction with a drinking water fountain, towels.

The W. C. walls are covered with rustless steel up to waist level; the floor is covered with asphalt blocks. The tanks fitted under the frames have a total capacity of 300 gallons and are put under pressure by compressed air. The tanks are insulated and fitted with a steam pipe to prevent them freezing up. Washing water is heated in winter.

The lavatories are provided with soap, towels and toilet paper. The lavatories are cleaned with a solution of water and creosote. A soap compound is used to clean the washbasins.

e) South African Railways.

The inside walls are covered with plywood and the floors with linoleum.

The dimensions of the luggage racks are:

1) blue train: 5′ 10″ × 16″ and 2′ 6″ × 9″ × 5′ 6″ under a double seat;

2) imported metal stock: 3′ 10 1/2″ × 14″ and 2′ 6″ × 9″ × 5′ 9″ under a double seat.

The fittings provided are: blinds, mirrors, shelves, ashtrays, coathooks, reading-lamps.

The walls of the W. C. are covered with Rexine attached to plywood panels or painted steel sheets. The floors are covered with rubber.

The capacity of the water tanks varies between 80 and 65 gallons according to the type of stock. Washing water is heated throughout the year. Soap, towels and toilet paper are provided in all the lavatories. The walls and floors of the latter are cleaned with soap solution. The washbasins are cleaned with a silicate powder and the lavatory pans with soap to which disinfectant has been added.

3) *Supplement.* — The inside decoration of the Sudan Railways coaches is in principle similar to that of coaches of the same class belonging to Railway Administrations of Colonies with similar climatic conditions.

* * *

E. RUNNING STABILITY.

1. Type of suspension.

In order to classify the types of suspension, we call primary suspension in what follows that between the axle boxes and bogie frame, and secondary suspension that between the bogie frame and the bolster or the body.

Type 1. — Primary suspension: laminated springs with coiled springs or compressed rubber at the ends.

Secondary suspension: nest of concentric coiled springs or separate spiral springs.

This is the type of suspension used on the British Railways, London Transport Executive and standard gauge coaches of the Indian Government Railways and Sudan Railways.

Type 2. — Primary suspension: laminated springs with coiled springs at the ends.

Secondary suspension: a group of 3 or 4 elliptical conjugated springs on each side of the bolster.

This is the type of bogie met with on the rail motor coaches of the South African Railways and the coaches of the New Zealand Railways.

Type 3. — Primary suspension: coiled springs between the frame and the equalizing bars.

Secondary suspension: nest of coiled springs with an elliptical conjugated spring on each side of the bolster.

This is the type of bogie adopted by the Penna in its recent designs of coaches and that of the rail motor coaches of the New Zealand Railways (imported 49/50).

Type 4. — Primary suspension: coiled springs between the frame and the equalizing bars.

Secondary suspension : nest of elliptical springs on each side of the bolster.

This is the so-called « Pennsylvania » bogie. It is found on the metric gauge coaches of the Indian Government Railways and on the main line coaches of the South African Railways as well as the rail motor coaches of the Victorian Railways.

Type 5. — Primary suspension : two coiled springs on each box.

Secondary suspension : nest of elliptical conjugated springs.

This type of bogie is commonly known as the « Argentine » and is found under the coaches of the Victorian Railways.

2. Characteristics and flexibility of the suspension gear.

Tables V and VI give details of the above mentioned characteristics.

In addition a few general remarks can be made regarding the replies received to the questionnaire sent to the different Administrations :

a) all the suspension gear used makes use of bolsters, with a single exception : the railcar trailers of the Victorian Railways rest directly on the bogie frames; this arrangement has been recently introduced, so that it is not possible to make any comments regarding the running;

b) no special precautions have been taken to damp out horizontal oscillations;

c) all the suspension gear described make use of laminated springs to damp out vertical oscillations; there is one exception however : the railcar bogies of the New Zealand Railways where hydraulic shock absorbers are used;

d) no special precautions are taken to diminish the vibrations of the central portion of the body in the case of light weight stock;

e) the standard profile of the tyres is 1/20, whatever the running speed of the stock in question. The British Railways however state that they have carried out trials before the war with a considerable number of vehicles having tyres of 1/100. The improvement in stability of running was remarkable, but on the other hand wear of the flanges occurred much more rapidly;

f) four and six wheeled vehicles do not come into the picture in the case of up to date stock.

3. Measuring the stability.

The Penna has carried out numerous tests of the stability. Accelerometers measuring the ratio between the acceleration and the terrestrial acceleration were used. The apparatus was of two types :

1) a type recording shocks by points and measuring the number;

2) a continuously recording type.

No results were given. The L. T. E. mentioned the Hallade apparatus. The S. A. R. state they made various measurements which were not in any way conclusive.

[656 .25]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

15th. SESSION (ROME, 1950).

QUESTION IX.

Modern safety and signal installations (centralising apparatus for block system and signals). — Central electric apparatus with individual levers and « all relay » levers (all electric interlocking). — Automatic block-system with continuous current and coded current. — Light and speed signalling.

REPORT

(Belgium and Colony, Denmark, France and Colonies, Luxemburg, Norway, Netherlands and Colonies, Poland, Switzerland and Syria),

by Ir. E. J. F. Derijckere,

Director of Electricity and Signalling Department, Belgian National Railways.

NOTE TO OUR READERS.

The following Report *replaces and cancels* the Report by Mr. Derijckere published in our *Bulletin* for May 1950, pp. 849/13 to 875/39.

Certain questions dealing with matters of principle and the methods of giving effect to them, relating to the points set forth above, having been brought forward already on the occasion of previous Sessions, the list of questions for submission to the present Congress has been drawn up principally with a view to their application to lines which are to be worked by electric traction.

At the present time when certain Railways propose to spend large capital sums for electrifying their lines, while at the same time increasing the speed of their trains, we have had under consideration the development of colour-light signalling and its adaptation to this new method of working. In addition, the increase in the density of the traffic which will result makes it necessary to look for means of obtaining very great rapidity in the setting up of routes in the signal boxes, while employing a minimum of staff and at the same time obtaining the maximum degree of safety.

Certain questions referring to the technical details of the design, either in the signal box or out on the line, have also been brought forward for consideration.

***

The list of questions was sent to Railway Administrations in the following countries :

Algeria;
Belgium and Colony;

Denmark;
France;
French Colonies & Protectorates;
Luxemburg;
Norway;
Netherlands & Colonies;
Poland;
Switzerland;
Syria;
Tunisia.

All have replied except Poland, either in the form of very valuable detailed information which will be set forth below, or by saying that the state of development of their Railways was not such as to justify as yet the installation of such an advanced type of signalling as that which will occupy us in the present report. We wish to express our thanks at this point to the engineers concerned on these different Railways for the kindness and readiness with which they have supplied us with the particulars on which our report is based.

We propose to divide it into four parts taking up and commenting upon the useful replies which we have received. In doing that we shall, in principle, take the various Railways in alphabetical order, introducing the replies with a commentary on them or following them with a conclusion.

CHAPTER I.

Light signals. Signalling for direction and speed.

1. *Do you find it necessary to give drivers direction indications? When do you do so, and how? What are the advantages?*
2. *Show by means of diagrams the aspects given by a series of signals and explain the meaning of these different aspects.*
3. *At a junction where the direction is signalled, the driver knows what direction he must take. With speed signals, he does not. Has it been proved that this is a drawback?*

ALGERIA.

The only junctions on the open line between stations on the Algerian Railways are plain junctions, with two routes.

One line has a speed limit of 30 km/h. (appr. 19 m.p.h.) and on the other the maximum speed allowed on the line may be observed.

The driver is informed of the route he is going to take by a reduced speed signal which, if turned so as to be invisible indicates that the direct route is set up, and if kept showing that the diverging route is to be taken.

At the outgoing end of stations the indication of the route set up is given in plain language by illuminated route indicators.

BELGIUM.

The geographical layout of the junction or entrance to a station is shown on an indicator board 300 m (328 yards) in rear of the signal itself. The *route set up* is shown next to this signal by a *luminous arrow* sign. The speed to be observed at the junction is given by luminous numerals expressing the numbers of kilometres per hour in tens.

Where the speed is the same as that allowed on that part of the line no numeral is shown.

At the outlet to stations the same arrangement is applied, except that the indicator board is placed nearer to the signal.

N. B. — The principles and methods of applying this type of signalling will be found explained in the article « New colour-light signalling adopted by the Belgian National Railways for electrified lines fitted with automatic signalling or interlocked block » published by the author of the present report in the *Bulletin of the International Railway Congress Association* for January 1949.

DENMARK.

The indication of the route set up is given by a luminous vertical bar for the

direct route and one inclined to the left or right to indicate a divergence in those directions. The Danish Railways propose, however, in due course to replace these route indications by speed indications.

FRANCE.

The French National Railways consider it necessary to give the driver an indication of the route he is to follow only in those cases where an indication of the speed to be observed is not in itself sufficient :

a) at an ordinary geographical type junction, with two routes only, one of these routes is ordinarily free to be taken at the maximum speed allowed on the line, the other at a lower speed, depending on the characteristics of the turnout.

In such a case an indication of the speed which must not be exceeded on the diverging route is considered to be a sufficient indication of the direction to be taken and the Railway attaches no importance to whether the divergence is to the left or the right;

b) in the case of a similar junction but having more than two routes, where, for example, one line may be travelled over at the maximum speed of the line, the second at say 70 km/h. (42 m.p.h.) (and consequently signalled by means of a speed board) and the third at say 30 km/h. (19 m.p.h.) (and therefore signalled by a reduced speed reminder signal preceded in rear by a reduced speed signal or a caution signal) the indication of the speed to be observed is also considered to afford sufficient indication of the route to be taken;

c) in the case of an equal speed junction, or where in the case of a junction including more than two directions, it is considered that an indication of the speed is insufficient to enable drivers to tell which route has been set up for them, a direction indicator is provided;

d) the indication of the direction to be taken is at times recalled to the driver's attention by means of boards inscribed in plain language placed ahead of the junction on each line. At times this can be the only route indication provided at all;

e) when one of the routes to which facing points lead gives access to a subsidiary line, such as an engine or carriage line, there may be provided, in addition to the speed indication (or the direction indicator) or even as the only indication of direction, a board marked G (garage = siding). This board which is fixed, if placed ahead of the points, or made to revolve if in rear of them, either recalls to the driver or, in the second case, indicates to him beforehand, that he is entering such a siding line (on which he must, of course, run prepared to stop short of any obstruction).

The French National Railways consider that the inherent advantages of using speed signalling to show the route set up are that it enables a reduction to be made in the amount of route signalling used and in the number of indications drivers are called on to observe.

B. The Paris Transport Board *always* gives an indication of the route set up when a train has to take points in the facing direction at such a speed that the driver has no chance of stopping clear of the points if he sees from their position that he is being sent along the wrong route.

LUXEMBURG.

When the home signal shows for one of the routes at a junction « Proceed at unrestricted speed » and for the other « Proceed at restricted speed », the Luxemburg Railways consider it superfluous to give an actual route indication, in view of the simple character of their Railway system. They only indicate the direction to be taken at a junction when the signal itself gives one and the same speed indication for the two routes.

This is done by means of large letters formed of white lights, giving the initial letter of the next station ahead. These Railways consider it useful to give drivers

an indication of the route set up in order to prevent a train taking the wrong line in consequence of a signalman's mistake.

MOROCCO.

Ordinary running junctions are signalled by junction semaphores with, should the circumstances require it, a speed board. At the outlet to stations luminous indication boards show which route has been set up.

NORWAY.

Direction is indicated on the Norwegian lines by giving the speed to be observed, as owing to the special layout of their Railway system there are no running junctions between stations.

At the entrance to stations where a train can be received on more than one track numerical type indicators are used with the signals.

NETHERLANDS.

The Dutch Railways consider that there is no need to indicate the route except at junctions where the speed is the same on both lines. In that case a luminous arrow sign may be used.

N. B. — The principles of the new Netherlands light signalling and their practical application were given in an article entitled « The destruction, rehabilitation and future development of the signalling on the Netherlands Railways » by Mr. J. H. VERSTEGEN, Chief Signal Engineer of those Railways in the *Bulletin of the International Railway Congress Association* for August 1948.

SWITZERLAND.

The Swiss Railways consider that in the majority of cases on their lines it is possible with speed signalling to indicate the route which is set up, direct or diverging. Where a speed indication alone is not sufficient to do that an indication board is provided.

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In order to enable the reader to obtain an idea of the chief signalling systems in use we have illustrated in our report (Figs 1 to 5) the methods of applying the Belgian, French, Swiss, Dutch and Norwegian colour light signalling systems to certain types of junction met with in practice.

The meaning of the various indications given is a follows :

BELGIUM. S.N.C.B. (Fig. 1).

1. Stop at the junction home signal.
2. Proceed at maximum permissible speed on the direct route.
3. Proceed on left-hand diverging route over points of ordinary type, maximum speed 40 km/h. (25 m.p.h.).
4. Proceed on left-hand diverging route over points of special type, say with spring pattern tongues, maximum speed 80 km/h. (50 m.p.h.).
5. Proceed on left-hand diverging route over special type points, maximum speed the same as for the direct route.
6. Proceed on right-hand diverging route over equal speed junction, or with points of special type, maximum speed 80 km/h.

FRANCE. S.N.C.F. (Fig. 2).

1. Stop at the junction home signal.
2. Proceed at maximum permissible speed on the direct route.
3. Proceed on left-hand diverging route over points of ordinary type, maximum speed 30 km/h.
4. Proceed on left-hand diverging route, over points of special type, say with spring pattern tongues, maximum speed 80 km/h.
5. Proceed on left-hand diverging route over equal speed junction, with points of special type, maximum speed 80 km/h.

SWITZERLAND (Fig. 3).

1. Stop at the junction home signal.
2. Proceed at maximum permissible speed on the direct route.

BELGIUM. *(S. N. C. B.)*

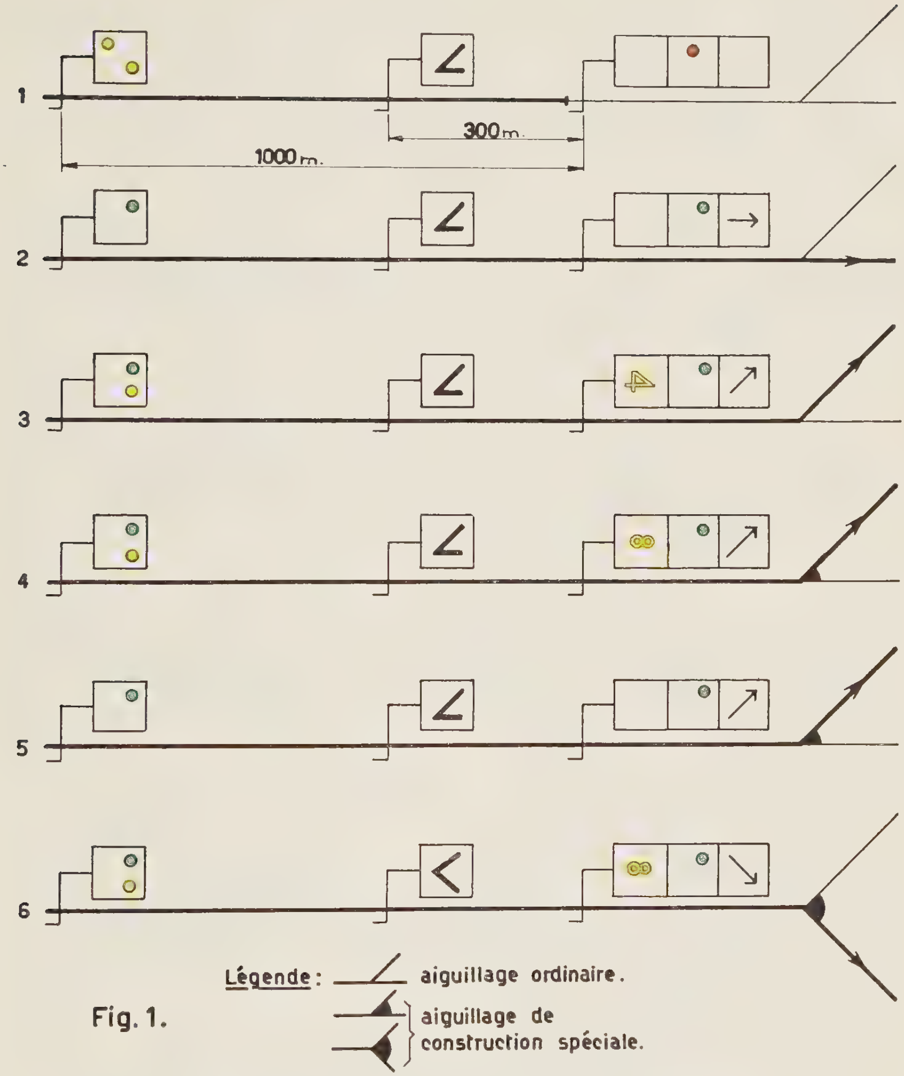

Fig. 1.

Explanation of French terms : Aiguillage ordinaire = Ordinary points. — Aiguillage de construction spéciale = Points of special construction.

3. Proceed on left-hand diverging route over ordinary type points, maximum speed 45 km/h.

4. Proceed on left-hand diverging route over special type points, say with spring type tongues, maximum speed may exceed 45 km/h.

5. Proceed on right-hand diverging route over ordinary type points, maximum speed 45 km/h. (28 m.p.h.).

FRANCE. (*S. N C. F.*)

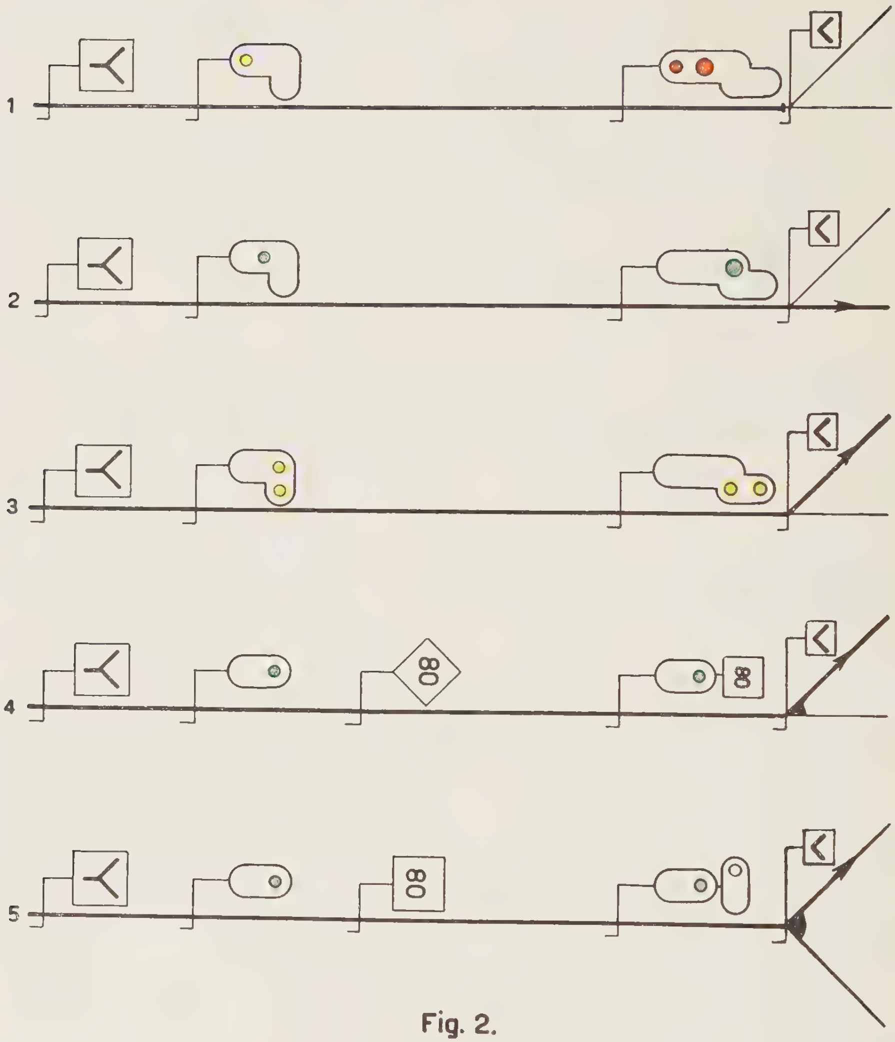

Fig. 2.

Légende : o feu blanc

Feu blanc = White light.

6. Proceed on right-hand diverging route over special type points, say with spring type tongues, maximum speed may exceed 45 km/h.

NETHERLANDS (Fig. 4).

1. Stop at the junction home signal.

2. Proceed at maximum permissible speed on direct route.

3. Proceed on right-hand diverging route over ordinary type points, maximum speed 45 km/h.

4. Proceed on right-hand diverging route

SWITZERLAND.

(C. F. F., Emmental-Burgdorf-Thun Bahn, Rhätische Bahn, Bern-Loetschberg-Simplon.)

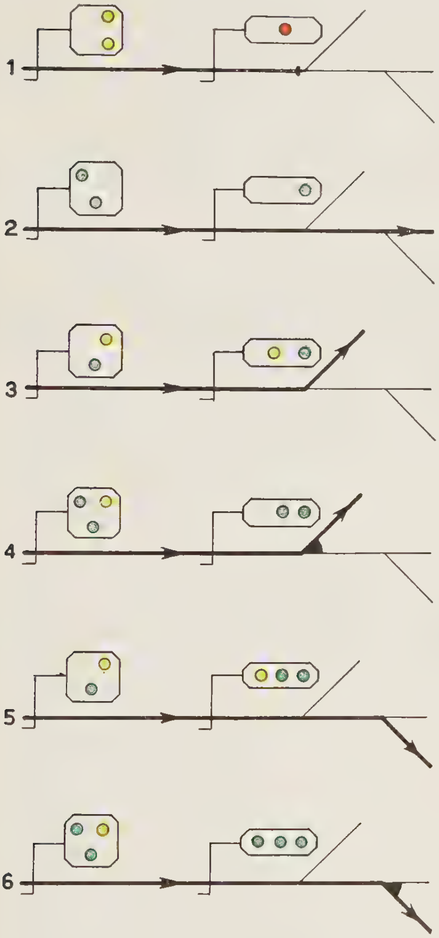

Fig. 3.

NETHERLANDS.

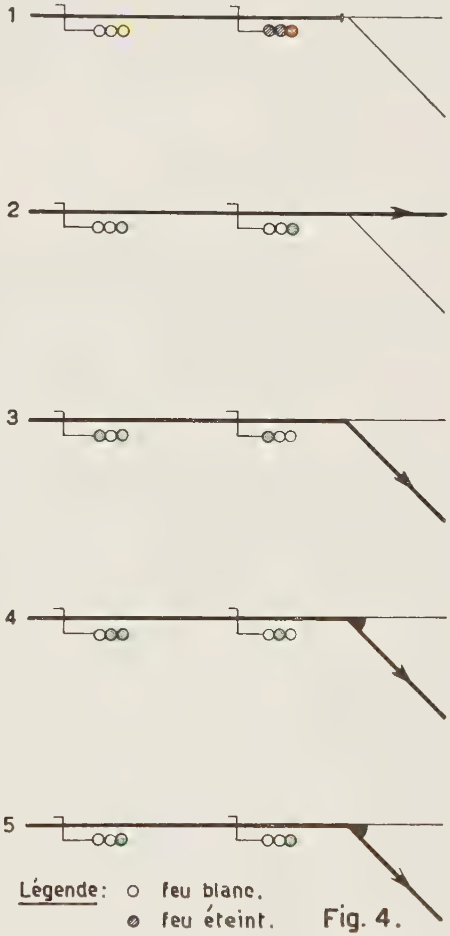

Fig. 4.

Feu blanc = White light. — Feu éteint = Light extinguished.

over special type points, maximum speed may exceed 45 km/h. but must be less than that applying to the direct route.

5. Proceed on right-hand diverging route over special type points, maximum speed the same as that applying to the direct route.

NORWAY (Fig. 5).

1. Stop at the junction home signal.
2. Run into station over diverging route
3. Stop at the starting signal.
4. Run through station at maximum permissible speed.

NORWAY. (*Norges Statsbauer.*)

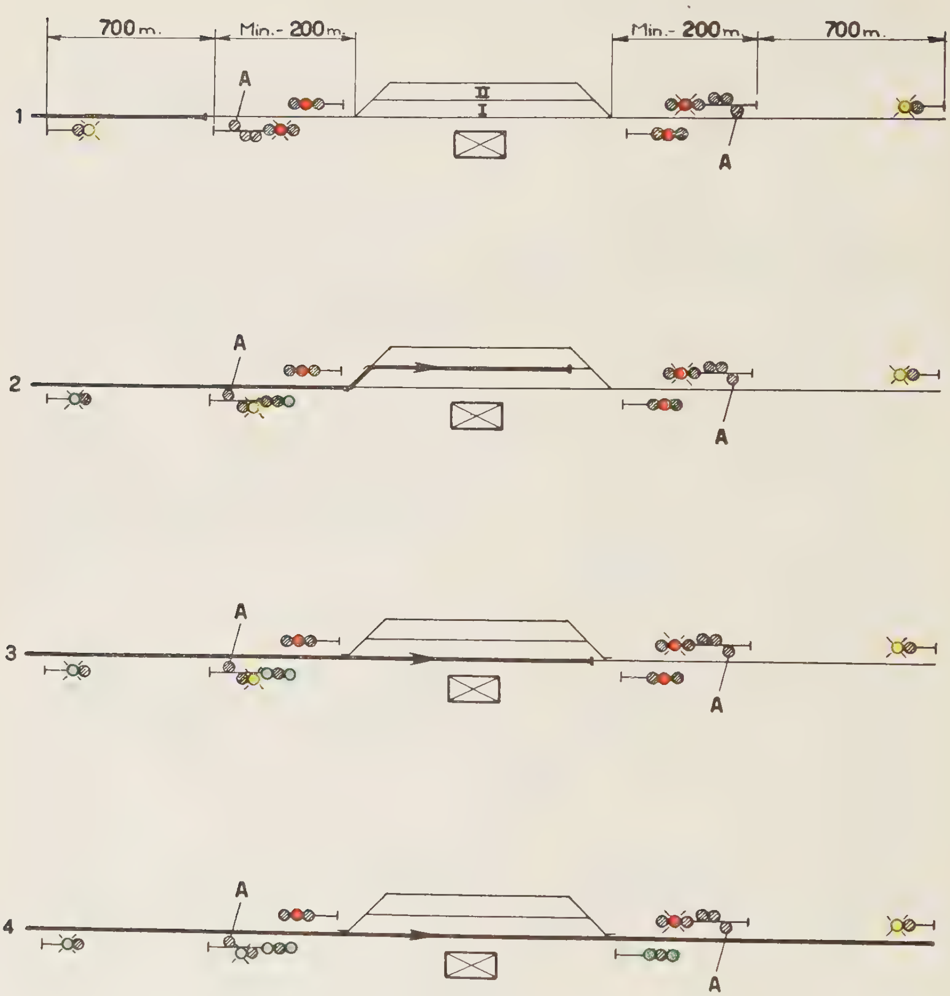

Fig. 5.

A : feu normalement éteint, qui devient blanc clignotant quand la gare n'est pas desservie et que la circulation se fait dans les deux sens sur la voie principale unique.

Légende : ☼ feu clignotant.
⊘ feu éteint.

Explanation of French terms : A. : light normally extinguished, becomes flashing white light when station is closed and when traffic is allowed in both directions on single main line.
Feu clignotant = Flashing light. — Feu éteint = Light extinguished.

N. B. — Lights A are normally out and are seen as white flashing lights when the station is closed and arrangements have been made to allow trains to run through in either direction at maximum permissible speed.

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From what has been given above, the following conclusions may be drawn, namely :

1. All Railway systems at the present time are adopting the red light in colour light signalling to indicate stop, either in rear of a junction or a station.

The multiple stop indications given by the bracket type signals on some lines are being given up. This is a matter for congratulation as it simplifies very greatly the reading of the signals at night at the entrance to the larger stations.

2. The caution indication, giving warning of the approach to a junction, is given either by one yellow light, or two yellow lights, or by a flashing yellow light, but in every instance by yellow alone, no light of another colour being seen with it.

This method of proceeding leads gradually to a second and very desirable step towards standardisation.

3. As regards indicating the route set up for a train, the solutions adopted vary very much as between the different Railways and conflicting opinions on it are held.

All the Railways are in agreement however in saying that in certain cases it is necessary to do so, and it is then done in different ways (see Figs. 1, 2 and 3 for example), often by means of a series of conventional aspects combining the ideas of speed and direction in an arbitrary manner. In the opinion of the author of this report this complicates the reading of the signals unnecessarily, especially on heavily worked lines and at the entrance to and outlet from the larger stations.

4. *What type of light signals do you use? With special red, yellow or red lenses, or the system making use of 2 or 3 light frames containing coloured glasses? Give the reasons for your choice.*

5. *What system do you use to make sure visibility is good at the foot of the signal? (« close up indication »).*

6. *What type of lamps do you use : with one or two filaments? Give the power and voltage of the lamps? What optical system is used : diameter of the outer lenses, horizontal and vertical dispersal?*

The reply to the questions set out above are given in tabular form hereafter (see pages 858/22 to 861/25).

The following conclusions may be drawn from the above :

1. The use of two or more lenses is generally preferred to the arrangement in which an internal spectacle (2 or 3 position) is used, because the layout of the lights on the background plate does not allow of the latter method being used economically.

The only management among those consulted to use the « searchlight » system is that of the Netherlands Railways and it does so because it meets the requirements of the new system of signal indications adopted by it. It is evident that no question of phantom indications can arise with this arrangement.

2. As regards close up visibility of a signal, the majority of lines use a deflector moulded in the body of the lens, or an independent and adjustable one.

One or two lines which do not use deflectors cause trains to stop at a distance of 20 m (22 yrds) in rear of the signal.

It is opportune to draw attention here to the great advantage of fixing the lights on a level with the driver's eye. This greatly facilitates picking up the lights, not only in fog but when a signal has to be observed at very close range.

Railway	Types of light signal used		Close up indication	Optical system
	Lens type	Searchlight type		
ALGERIA.	As on the S. N. C. F.	—	Deflecting unit in the outer lens itself or mounted in front of it.	2 lens with loured glass tween the in lens and la
BELGIUM. *(S. N. C. B.)*	Lens type	—	Deflecting unit in the outer lens itself sending a small beam of light over an angle of 20° to 45° measured with respect to the plane of the light.	— do —
DENMARK.	Lens type	The use of this type is being considered for signals in tunnels or where space is restricted and the lens type of signal cannot be fixed.	Deflecting unit giving a partly horizontal and partly vertical dispersion.	Two lenses of which is loured.
FRANCE. *(S. N. C. F.)*	Lens type	—	Deflecting unit fixed inside the optical assembly and adjustable.	Two lenses loured glass tween the in lens and lamp.
FRANCE. *(Paris Transport Board)*	Lens type	—	*City or Inner Metropolitan Lines.* The optical systems of these signals do the light beam in a tunnel need only be of l the lights being on a level with- and at a sh	
	Lens type	—	*Sceaux Line.* The lenses include a deflecting unit.	As on the *S. N. C.*

)iameter of uter lens	Dispersion		Lamps		
	horizontal	vertical	Number of filaments	Voltage	Wattage
220 mm	4°	4°	1	7.2 V	15 W
160 mm	4°, 10° and 20° on curves	$1^{\circ}\ 3'$	1	7.2 V	15 W
200 mm	4° and 16°	—	2-one in reserve coming into action when first is burnt out.	30 V	15 W
220 mm he principal lights, 160 mm the second light of the indication for the re- ed speed and iced speed inder indic- ns.	4°, 10° and 20° on curves.	$1^{\circ}\ 30'$	1	8 V	10 W for 4° horizontal dispersion, 15 W for 10° and 25° W for 20°
sent any interesting characteristics, seeing that ensity. No deflecting arrangement is used, ance from the motorman's eye.			1 However two lamps are used (one being in reserve) with automatic change-over in event of failure. In future units containing low voltage lamps, with 2 filaments, one 10W and the other 5W will be used.	130 V	25 W
160 mm	As on the *S. N. C. F.*			7.5 V	—

Railway	Types of light signal used		Close up indication	Optica[l] system
	Lens type	Searchlight type		
LUXEMBURG.	Lens type	—	Deflecting mirror in the interior of the optical assembly above the lamp (for the red lights only).	Two lense[s] of them co[...] ed.
MOROCCO.	Lens type	—	No special device used.	— do —
NORWAY.	Lens type	—	No special device is used as trains are required to stop at least 20 m (app. 22 yards) in rear of the signal and the highest light is at 5.40 m (17.71 feet) above rail level.	— do —
NETHERLANDS.	—	Searchlight type with 3-colour internal spectacle.	Lens with deflecting prism (40° downwards formed in the « hot spot » position).	Fresnel le[ns]
SWITZERLAND. *(Federal and Emmental-Burgdorf-Thun line).*	Lens type	—	No deflecting device is used.	Two lense[s] coloured.
SWITZERLAND. *(Rhaetian Railway).*	Lens type	—	No deflecting device is used. Trains stop 20 m in rear of the signal.	— do

Diameter of [...]ter lens	Dispersion		Lamps		
	horizontal	vertical	Number of filaments	Voltage	Wattage
60 mm	8°, 20° and 30° on curves.	—	1	40 V	20 W
60 mm	12°, 24°	12°, 24°	1	5.7 V, 7.5 V or 5 V	10 W 15 W
[...]10 mm	8°, 30°	not specified.	1 or 2 according to circumstances: 1 filament in the caution (distant) signals; 2 filaments both burning, one more than the other, in home and ordinary block signals.	10 V	20 W 40 W
[...]10 mm	2° in all directions About 15° and 30° on curves.	2°	1	11.3 V	13.3 W run at a voltage of 10 V in actual service.
60 mm	8°, 20° and 30°	not specified.	1	40 V	20 W
60 mm	8°, 20°, and 30°	—	1	40 V	20 W

3. As regards the diameter of the outer lenses of signals, the sizes 220 mm (8.66 in.) and 160 mm (6.29 in.) are both used.

The experience of the author has been that 160 mm (6.29 in.) diameter lenses allow of fixing at 0.60 m (1.96 ft.) centre to centre, while the 220 mm lenses necessitate a spacing of 0.70 m (2.29 ft.) to enable two or more lights on a signal background plate to be seen clearly at some distance. This means that the use of 160 mm lenses enables the size of the backgrounds to be reduced, which is of advantage on an electrified line carrying heavy traffic.

4. The spread of the light beam varies from one Railway to another, but it can be said that the tendency is towards reducing it so as to concentrate the beam as much as possible, at all events on straight track.

5. As regards the lamps themselves, they vary very much both as to type and voltage. It can be said, however, that the tendency is towards using a single filament lamp of moderate voltage 7 to 8 volts, and of medium wattage, say 15.

7. *Are the signals worked directly from the signal boxes or are relays used at the foot of the signal? Do you repeat the signal lights in the signal box?*

8. *Do you check the lighting of the signal lights before allowing the upper lights to be lighted? If so, what system do you make use of?*

ALGERIA.

The lights are proved or detected in the signal box by a relay the contacts of which are in the feed circuit of the caution relay of the signal in the rear.

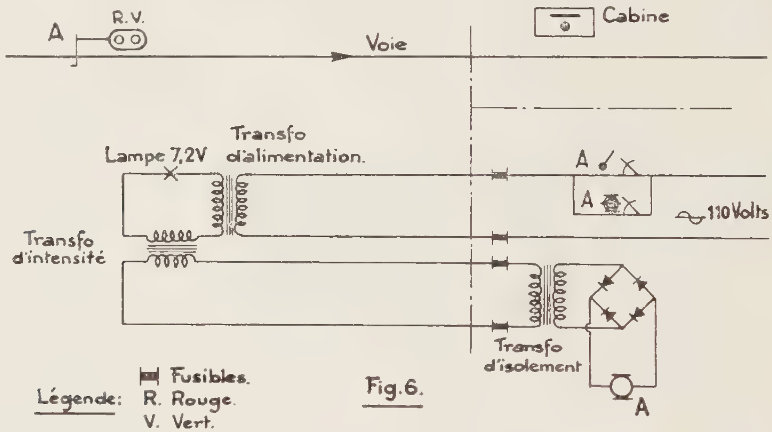

Fig. 6.

Voie = Track. — Cabine = Sig. box. — Transfo d'alimentation = Feed transformer — Transfo d'intensité = Voltage transf. — Transfo d'isolement = Isolating transf. — Fusibles = Fuses — Rouge = Red. — Vert = Green.

BELGIUM. S. N. C. B.

When manual block working is in force all lights are proved in the signal box, the aspects of the signals being continuously repeated on the illuminated track diagram (see Fig. 6). It should be pointed out that we are referring to circuit arrangements applied on lines worked by 3 000 D. C. traction.

In the case of manually worked colour-light signals operated in conjunction with interlocked block, the setting of each signal to « proceed » is dependent on receipt of a release from the signal box in advance, and this can only be sent if the correspond-

ing signal at that box has gone to danger behind the preceding train. Where the signalling is automatic there is no repeating in any signal box.

to « proceed » is solely determined by the action of the track relays. As regards the « caution » function of a signal, this of course is governed, in the signal in rear,

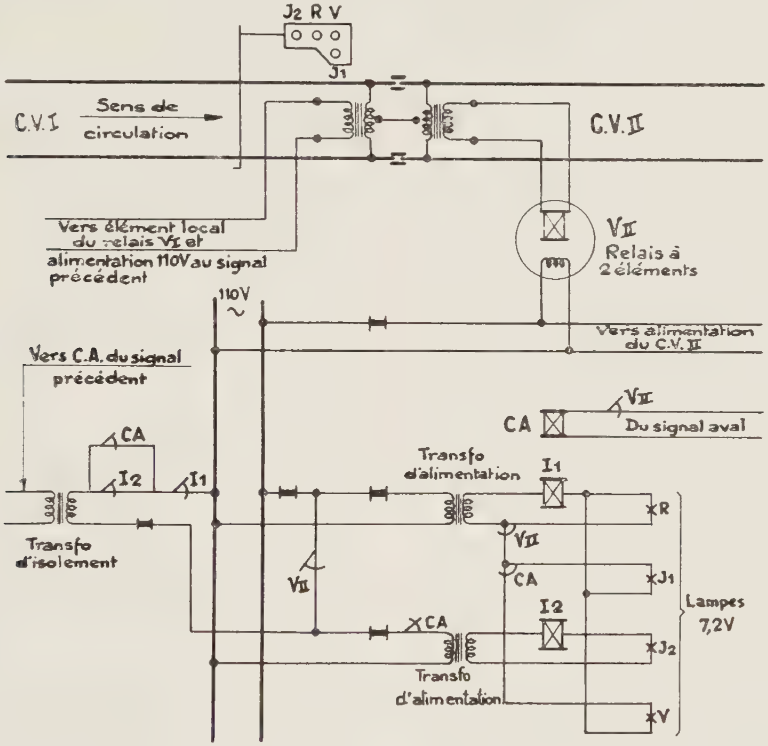

Fig. 7.

Légende : ⧓ : fusibles.
R : rouge.
V : vert.
J : jaune.
C.A. : contrôle avertissement.
I1, I2 : relais d'intensité.

Fusibles = Fuses. — Rouge = Red. — Vert = Green. — Jaune = Yellow. — Sens de circulation = Direction of traffic — C. V. = track circuit — Contrôle d'avertissement = proving in caution indication circuit — Vers élément local du relais VI et alimentation 110 V au signal précédent = To local element of relay VI and 110 V. feed to the preceding signal.— Vers C. A. du signal précédent = Caution proving signal to signal in the rear. — Vers alimentation du C. V. II = To feed to track circuit II. — Du signal aval = From the signal in advance. — Relais d'intensité = Voltage proving relay or relays. — Relais à deux éléments = Double element relay.

The production of the « proceed » aspect in an automatic signal however, is not made dependent on the next signal in advance going to danger behind the previous train; this change, from « stop »

by the aspect exhibited by the signal in advance (see Fig. 7).

It should be noted that in Fig. 6 and 7 no current is assumed to be flowing in any circuit and all relays are de-energised.

DENMARK.

All lights are proved in the signal box by relays and repeater lamps. The proving of the lights of the signal in advance is effected by relays, the contacts of which are in the feed circuit to the lights of the signal in the rear.

FRANCE. S. N. C. F.

Advantage is taken of the technical features of light signals to simplify the testing circuits.

Practically speaking such proving is confined to that of detecting that a signal worked from a signal box has been put to danger as intended, without actually repeating the aspect produced and the corresponding lights, and proving also similarly the relative distant or caution signal.

The aspects shown by automatic signals are no longer proved in any way. As a result of applying these principles, the lights are not detected, neither in the signal box in the form of special proving arrangements, nor on the ground, by making the illumination of one signal dependent on that of another. On the other hand, to help the drivers, any signal the lights of which are out, is automatically proved at the signal in rear, but causing such signal to show « caution » in such circumstances.

FRANCE. (Paris Transport Board).

All lights controlled from a signal box are proved in that box on an illuminated diagram by the use of relays, but this is not done in the case of automatic signals.

The reply to question 8 is in the negative.

LUXEMBURG.

All signal lights are proved and repeated in the signal box, and the illumination of the lamps in a distant signal depends on a moving relay in the circuit of the stop signal ahead.

MOROCCO.

All signal lights are proved and repeated in the signal box. The reply to question 8 is negative.

NORWAY.

All signal lights are proved and repeated in the signal box without the use of relays. The lights are simply repeated directly. Automatic signals are not proved. The reply to question 8 is negative.

NETHERLANDS.

The « stop » and « proceed » aspects of signals are proved in the signal box. The reply to question 8 is negative.

SWITZERLAND.

All lights are repeated and therefore are proved in the signal box. The fact that a signal is illuminated is proved before the signal in rear can become so, by placing the contacts of the moving relay of one signal in the feed to the signal in the rear.

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From the above replies it may be concluded that no Railway as yet places absolute confidence in the working of relays, but a clear tendency is noticeable to place growing confidence in those types of relays, the manufacture of which has, in recent years, attained a high degree of perfection.

9. *Do you use winking lights? If so, for what reason and at what periodicity?*

The Algerian, Belgian, French, Luxemburg, Moroccan and Swiss lines do not use flashing lights in their ordinary running signalling.

The Danish lines use them in distant signals, with 60 flashes per minute.

The Norwegian lines use them at 60 flashes per minute for the red lights

protecting the entry to stations and movable bridges. In addition all yellow and green indications in the caution or distant signals are flashing.

The Netherlands Railways use a light flashing at 180 to the minute as a calling-on signal, to show that the track ahead is occupied, and one flashing at 75 to the minute for signals which are less than braking distance from the stop signal ahead.

The conclusion to be drawn from this is that in general, except in Norway and Denmark, flashing lights are not used in main running signals.

The Belgian Railways, however, intend to use lights flashing at 60 flashes per minute to control wrong line movements on electrified routes (see Question 13 below) in order to prevent any confusion at the entrance to a station where there are four tracks and the signals for the adjacent running lines being read by mistake.

10. *What precautions do you take to prevent the yellow light being confused with the red, and vice versa?*

Of all the Railways here concerned, only the Belgian and Swiss have adopted the following rule : a yellow light is never seen by itself, but a red light is invariably shown singly. This means that in order to avoid confusion between a yellow and a red light, the various combinations of lights are so arranged that yellow is always combined with another yellow or with one or more green lights, while the red indicating « stop » is always seen by iself.

The other lines rely on the technical specifications which lay down certain characteristics for the yellow and red glasses. Thus the Netherlands adopt the rules of the Association of American Railroads, while France has developed colour filters giving clearly defined transmission curves.

For any given filter the transmission curve must lie between those for standard glasses of light and dark hue selected since 1936 as a result of many tests made under practical conditions of observation and visibility, and extending over a wide range of coloured glasses.

Since that date many other visual tests have been made to check the matter and no criticism of the selected standards has been made.

In conclusion, it may be pointed out that all Railways have periodical eyesight tests for the drivers.

11. *Are you proposing to use light signals systematically on your electrified lines?*

12. *If the electrification is being carried out with overhead lines, will the signals be fastened to the catenary posts? Are there any drawbacks to this?*

13. *Do you use special signals for trains running in the wrong direction on one of two tracks in the case of an electrified line, to enable maintenance of the catenary lines to be carried out with one line temporarily out of service?*

All the managements consulted, except the S. N. C. F. and the Algerian and Moroccan lines, intend to adopt light signalling systematically from the commencement of electrification.

However, in France, as automatic signalling is generally installed when electrification is introduced, light signalling follows more or less quickly.

It appears that it is the form of mechanical type signal used that makes it possible in France (and in Switzerland too notably) to retain for a certain length of time the mechanical type of signalling before adopting the colour light system.

All the Railways are in agreement in not attaching the signals to the overhead traction catenary standards except in certain large and complicated stations when

the signal gantries span several tracks and serve at times to support the traction wires, special precautions being taken to insulate the signals from the traction voltage. However in the Netherlands signals of small case are at times attached to the traction standards.

The reasons given by the various lines for adopting this practice are as follows :

1. Keeping the signal supports separate from the traction standards allows at all times of arranging the spacing of the signals to suit the traffic working requirements;

2. When colour light signals are attached to the traction standards the vibrations set up in the latter are liable to make the light beams vibrate also and to cause the lamp filaments to fail.

Of all the lines consulted which possess electrified double track only the Norwegians use wrong line signalling in order to allow the traction overhead line to be inspected and overhauled while the track concerned is out of use.

Belgium and Denmark propose to use in future on electrified lines wrong line signalling, in consequence of the dense traffic which does not allow of the maintenance being done in the intervals between trains.

France and Switzerland have in view using at times a temporary wrong-line signalling arrangement.

We may point out, that the S. N. C. F. is at present installing signalling for both directions of running on parts of its double track Paris-Dijon line now being electrified; but this common user of track is being provided for the special purpose of increasing the carrying capacity of the line, a four track route for the greater part of its length.

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CHAPTER II.

Centralised electrical operation of signals with interlocking levers or with the free push button system.

1. *What system do you prefer in the case of large installations; for what reason?*
2. *Do you prefer mechanical or electrical interlocking, where individual levers are used?*

Replies are as follows :

ALGERIA.	The Algerian Railways have only one signal box of electro-mechanical type with individual levers for the points and route levers for the signals.	Interlocking is of electro-mechanical type.
BELGIUM.	Up to the present time all power signal boxes on the Belgian Railways have been of the electric type with individual operation of the points and signals. There are a few boxes with route-signal levers. A panel with free push-buttons is under construction.	Interlocking is of the electro-mechanical type, formed for the most part of a locking box with locking tappets and dogs, and other dogs acted on by electric locks.
DENMARK.	The Danish lines have up to the present used only individual operation of points and signals, but a panel with free push-buttons is under construction.	Electric interlocking is used.

FRANCE. (S. N. C. F.)	For many years past the French lines have used in the large stations power signal boxes equipped with route-levers formed of a mechanically interlocked combiner containing the levers and electric locks for effecting approach and route locking, etc. These signal boxes give entire satisfaction both from the point of view of traffic working and the technical point of view. The S. N. C. F. has also now built some important signal boxes with the free push-buttons, and several other very important ones are in course of construction.	Interlocking is of electro-mechanical type.
FRANCE. (Paris Transport Board.)	The route lever system and the free push-button arrangement are used on these lines. A panel on the latter system is in course of construction.	Interlocking is either electro-mechanical or electrical.
NORWAY.	On the Norwegian lines signal boxes with free push-buttons are now preferred, and no other type is now being installed at either large or small stations.	Interlocking is electrical.
NETHERLANDS.	On the Netherlands lines there are power frames with individual point and signal levers, and so called route-signal levers, left and right. It is intended in future to use on an extensive scale the NX system, and a large installation of this kind will shortly be in service.	Interlocking is a combination of mechanical and electrical mechanism.
SWITZERLAND.	On the various Swiss lines signal boxes with individual levers and route-signal levers have been installed. Two free push-button installations are under construction.	Interlocking is mechanical or electrical.

* * *

Those Railways which continue to use mechanical interlocking consider that it constitutes a safeguard in that it facilitates the carrying out of work during such times as certain electrical safeguards are out of service. However, it would appear that the use of relays with removable taps, that can be taken away in one piece, will facilitate the carrying out of work without having to use mechanical locking.

The advantages which the various lines see in the free push-button type signal boxes are as follows :

1. Signal boxes in which the levers or handles are not locked at any time allow of the controlling portions of the apparatus being reduced in size and consequently the corresponding panels or frames, which allows of the area of lines worked from a

box being increased, all the more that such signal boxes are well adapted to remote control and at the same time allow of the work of the signalmen being made easier.

2. Such signal boxes lend themselves to the use of automatic cancelling of routes as well as storage of the controls that have been set up. These two arrangements bring a considerable simplification of the signalman's work, leaving him free to devote his attention to the mental portion of it. Fewer signalmen are needed and the result is to obtain a flexible and simple means of handling a dense traffic.

3. It is not necessary for the relay room to be adjacent to the controlling desk or panel and this generally enables the size of the buildings required to be reduced.

4. Certain lines, such as those in Norway or those of the Paris Transport Board think that any change in an installation is more readily effected under the individual lever system using ordinary interlocking.

3. *Do you make use of selection in order to reduce the number of levers, e.g. one lever to work a signal controlling several routes?*

Certain lines using, or having used, individual lever type signal boxes, have replied in the affirmative, namely the Danish, Belgian and Swiss. These signal boxes are arranged with a single signal lever applying to a certain direction, the routes converging towards that direction being set up by levers having some preliminary selection.

4. *If push-buttons are used, are these fitted on a geographical panel or a separate desk panel?*

The Belgian, Danish and French lines use buttons mounted on a desk separated from the illuminated diagram, for the following reasons:

1) ease of mounting and of making any alteration to the desk;

2) ease of control of the traffic operations by the signalman, placed at sufficient distance from the diagram.

The Netherlands and Swiss lines have decided to make an initial application of the arrangement in which the buttons are placed in their geographical positions on the diagram. Norway states that a trial installation of this method will be made there.

5. *Is it possible to make an automatic selection of the possible routes between two points, so that the first free route is chosen, according to an order laid down in advance? What system is used?*

On the Dutch lines, with the NX system, using « entrance » and « exit » buttons, it is stated to be possible to introduce automatic selection of the routes that can be set up between two points.

6. *Compare the technical advantages of the two systems.*

In addition to the advantages mentioned under 1. above, the S. N. C. F. remarks that this type of signal box allows of dispensing with the use of electro-mechanical type locks, used so extensively in boxes having interlocked levers. (The lock is a somewhat delicate device calling for careful maintenance).

Besides this these signal boxes have traffic operating possibilities peculiar to themselves, automatic cancelling of routes, and storage of controls.

As regards the interlocked lever type, the capacity of which is in the neighbourhood of 200 routes, they do offer certain facilities during such times as a failure makes itself felt.

Generally it can be concluded that with the free push-button panels all locking of the operating mechanisms is effected by interrupting their control circuits and not by locking mechanically or electrically the actual parts used to control these appliances.

The substitution of the action of relays on the controlling circuits for that of electric locks or ordinary interlocking on the

controlling levers is of real interest and gets rid of the work of the fitter in the future.

7. *Is it not a fact that greater technical knowledge is necessary for the staff maintaining push button installations?*

8. *In view of the more complicated mechanism of push button systems, what steps have you taken to assure their proper maintenance?*

Only those Railways which have had considerable experience with the system using free push-buttons are able to provide replies to these questions. These are the French and Norwegian lines. We cannot do better than give the actual wording of the French reply.

The staff dealing with the maintenance of such installations must of course have had some special training and have attained a certain level of technical ability. Its work is however made easy on the one hand by the relatively simple circuit arrangements adopted, and on the other by certain special methods of assembling the equipment.

Thus complete assemblies or units are provided made up of several relays, which operate together to perform a certain function, mounted together on a movable frame.

In this way the technical knowledge required by the maintenance staff is lessened and all that has to be done should any part get out of order is to remove the defective unit and replace it by another taken from stores.

It is to be noted that the replacement of a unit or a relay at a location is effected very rapidly, free from all risk of making a false connection in the wiring, thanks to the automatic connecting devices provided with this kind of apparatus.

The reply received from the Norwegian Railways confirms the opinion expressed by the French Railways.

9. *Make the comparison of the two systems from the points of view of prime cost and maintenance.*

In this case also we give the actual reply received from the French lines.

The example on which this comparison is based is that of an important S. N. C. F. station (Montereau: with 120 points, 70 colour light signals and 338 routes, at present in course of being fitted up). The solution adopted is that of a central signal box of the all-relay type, with free levers.

Had it been decided to use interlocked levers two signal boxes would have had to be provided.

A comparison shows that the costs of the free lever system, buildings included, are about 10 % less than with the other arrangement. In addition the two signal boxes with interlocked levers would have required twice as many signalmen as the central all-relay signal box.

As regards the number of men engaged on maintenance, this can be regarded as being the same in either case. In fact the additional electric equipment which, in the free lever type of box, makes up for the economy afforded by the mechanical combiner or frame, does not appear to call for more maintenance than the combiner does, taking into account the particular arrangements adopted. At the moment, as stated above, the staff may call for some special training, and this presents no difficulty.

The Norwegian Railways point out, on the other hand, that the free lever type signal boxes require a summary monthly inspection and a thorough overhaul annually.

10. *Does a break down in a push button system have greater repercussions on the operating and traffic than a breakdown in an interlocking system?*

Certain Railways think that such is the case, whether the interlocked levers are of the individual or the route pattern.

The French Railways, which have had considerable experience with the free

push-button equipment, consider that this arrangement does definitely give rise to more serious problems for the traffic department, should a failure occur, than does the interlocked lever type of signal box. However it is thought that this small disadvantage is largely compensated by the many advantages of the free push-button type.

11. *What are the advantages and drawbacks of electrical control and electro-pneumatic control of the points?*

No Railway among those consulted uses the electro-pneumatic system. We cannot do better, we think, than give the reasons advanced by the S. N. C. F. with which we are in entire agreement.

1. Electro-pneumatic operation requires the same electric controlling and proving, or detecting circuits as does electric operation. It requires in addition equipment for producing and distributing the compressed air, which, in addition to costing money calls for careful and skilled maintenance.

2. The working efficiency of electrical control is much greater than that of a compressed air system.

3. The use of an electric motor allows of points being reversed sufficiently rapidly (in 3 seconds at the most in the case of points on running lines and 0.4 seconds in the case of marshalling yard points) and the movement is less violent than it is with the electro-pneumatic system.

4. Generally speaking electric operation is more flexible and allows of the direction of movement being instantly reversed should the controlling lever or handle be returned to its original position, which is difficult to arrange with the electro-pneumatic system.

12. *What steps have you taken to avoid having to use temporary signals when the points have been run through in the wrong direction and damaged?*

All the Railways adopt positive and constant detection of the points by means of the circuits controlling the clearing of the signals reading over the routes in which the points are included.

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CHAPTER III.

Distance control and operation of points and signals by means of relays.

The following is the list of questions relating to this matter:

1. *To what extent have you made use of the system:*
   a) *on single track lines;*
   b) *on double or multiple track lines?*
2. *What signalling system did it replace:*
   a) *on single track lines;*
   b) *on double or multiple track lines?*
3. *For what reason has it been used?*
4. *Do you intend to extend it?*
5. *What are the principal advantages?*
6. *What arrangements have been made to ensure the efficient maintenance of the equipment?*
7. *Do you have any difficulty in getting suitable staff for such maintenance work?*

Only the Belgian, Danish, French, Netherlands and Norwegian lines have replied. The others are not contemplating the use of remote control installations.

The particulars received are given below:

BELGIUM. (S. N. C. B.)

1. This system has not yet been applied on the lines of the S. N. C. B.

2-3. In default of the existence of any practical application of the system it is not possible to reply to these questions.

4. The S. N. C. B. is in course of installing such an arrangement at a junction to be worked from a signal box 3.5 km (2.17 miles) away from it.

It proposes to extend it to cover three junctions situated at several kilometres from an interchange station so as to concentrate the whole of the working in one all-relay signal box.

5. The principal advantages of concentrating the working at one control point appear to be :

a) greater flexibility in the working of the traffic, in consequence of the unified control over it given by the arrangement;

b) in the reduction in staff which it makes possible.

This brings a real saving only when the capital cost of construction is not excessive. This condition can only be realised if the operating and moving circuits for the remote control require only a small number of wires.

6. Lack of experience prevents a reply being given to this question.

7. In view of the technical standard of our present maintenance staff we do not anticipate any difficulty in finding suitable persons for the work.

DENMARK.

1. The system is being put in on several single track lines.

2. The long distance control usually replaces mechanical double-wire equipment.

3. The advantages claimed for it are as follows :

a) the controlling apparatus occupies but little space and can be installed at the place most favourable to its operation;

b) savings are obtained in the cost of building signal box structures;

c) the relays used can be standardised and in consequence lend themselves to massed repetition production;

d) electrical is preferred to mechanical interlocking.

4. The Danish Railways are going to extend the system to other lines.

5. See 3.

6. Having regard to the fact that the relays are of the plug-in type and allow of being replaced without any risk of mistake, no difficulty in maintaining the apparatus is anticipated. In addition the repair and overhaul of these relays is done in special workshops.

7. There are no difficulties under this heading.

FRANCE. (S. N. C. F.)

1. The S. N. C. F. has used remote control for both operating and proving circuits :

a) for controlling at a distance, from some pre-determined point isolated layouts (junctions, entrances to reception lines). The first instance of this was at Onville Junction, installed in 1934;

b) for concentrating at one central point (central signal box) the controlling and proving of all the points and signals of a station, using remote control for the areas situated at a distance from the signal box :

— an installation is in course of construction at Montereau with 338 routes (two junctions located some few kilometres distant will at the same time, be brought under the control of the signal box);

— another installation at Juvisy, with 720 routes, is being designed;

c) for setting up centralised traffic control.

The first installation was put into service in 1933 between Houilles and Sartrouville, about 3 km (1.86 miles) covering 3 tracks, one being arranged for traffic in either direction operated by remote control by the traffic controller at Paris St. Lazare, 15 km (9 miles) distant :

— there are now under construction two double track sections (with both tracks arranged for two-way working) on the Paris-Lyons main line;

— first section : Dijon-Blaisy Bas, 27 km (16 miles);

— second section : Les Laumes-St. Florentin, 84 km (52 miles).

The remote control of these sections will be in the hands of the traffic controller at Dijon. The installation between Houilles and Sartrouville uses the individual lever arrangement, but the work being put in on the Paris-Lyons line will be the first installation of centralised control using route-levers.

N. B. — With the exception of the type known as P. S. A. (postes semi-autonomes = semi-independent signal boxes) in use at Onville, which uses a step-by-step (pas-à-pas) mechanism, all the others have all-relay equipment.

2. The S.N. C. F. considers that remote control does not constitute a signalling system in itself but a technical basis on which to carry out an installation, particularly suited to solving certain operating problems in certain circumstances.

3. The reasons which have guided the S. N. C. F. in the choice of the applications considered in the reply to Question 1 are based essentially on the following considerations :

a) the concentration of the working in one hand enables appreciable economies in staff to be realised, together with greater operating facilities;

b) in particular when a whole section of line is involved this concentration allows of the actual traffic operation over it being placed in the hands of the controller, which eliminates loss of time in transmitting orders and avoids delay in executing them;

c) thanks to the tracks being made available for trains in either direction it is possible to make the maximum use of one or more of them, which avoids the necessity of having to put down additional tracks.

4. Having regard to the satisfactory results obtained, the S. N. C. F. intends to extend the system in so far as circumstances permit.

It has already elaborated a formula « safety, regularity and speed » applicable particularly to the problem set forth. This formula will be applied more especially in the case of the installations at Montereau and Juvisy. (Detailed particulars of the system will be found in an article by M. WALTER, Chief of the Signals, Telecommunications and Overhead Lines Department, S. N. C. F. entitled « A new type of route-lever signal box » in the April 1948 issue of the *Bulletin of the International Union of Railways.*)

5. See 3 and 4.

6. Remote control installation comprises essentially the following :

— the equipment for transmitting to a distance the operating and detecting or proving impulses;
— the signal box (or boxes) out along the line.

The maintenance of the transmitting apparatus is made comparatively easy by the general use of removable units with plug (or equivalent) connections.

7. Taking into account the arrangements applied, and mentioned in the preceding reply, there are no particular difficulties in finding and training the staff required to maintain such an installation, as is proved by the experience gained by the S. N. C. F. with the working of the Houilles-Sartrouville C. T. C. installation of 1933.

NORWAY.

1. A few examples of remote control have been installed, notably at junctions situated at a distance from stations, using a 4-core cable (centralised traffic control system).

2. Some old mechanical installations have been replaced by remote control equipment.

3. The reasons for installing remote control are, in order of importance :

a) economy in operating staff;
b) lower maintenance costs;
c) less risk of mistakes in working.

4. It is intended to extend the system in those cases where the advantages mentioned above are appreciably felt.

5. See 3.

6. Proper qualified staff is appointed to attend to the maintenance.

7. No difficulty has been experienced under this heading.

NETHERLANDS.

1. The system has been applied only to a few isolated sets of points.

2-3.

4. It is expected to use the C. T. C. on a single line to avoid doubling.

5. The advantages thought to be obtained are :

a) economy in operating staff;

b) better regulation of the train service with increase in the density of the traffic on a line.

6-7.

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CHAPTER IV.

The automatic block with track circuits using a permanent or coded flow of current.

1. *Do you make use of track circuits worked by permanent or coded current for the automatic block signals? What do you consider the maximum length advisable for the track circuits in each case?*

   What shunt is obtained by the train with track circuits of 500, 1 000, 1 500 and 2 000 m (546, 1 093, 1 640 and 2 187 yards) with :

   a) *direct current;*

   b) *alternating current without inductive connections;*

   c) *alternating current with inductive connections;*

   d) *coded current.*

The S. N. C. F. is the only Railway concerned which reports using coded track circuits.

They mention :

— some 30 track circuits controlling automatic signals and fed by direct current on the Petite Ceinture, Paris (maximum length of track circuit, 1 500 m;

— some twenty A. C. track circuits controlling similar signals on the Grande Ceinture, Paris (maximum length of track circuit, 1 500 m);

— a dozen isolated point locking track circuits using pulsating direct current (maximum length 500 m [546 yards]).

Most Railway systems consider that the maximum length of track circuit fed with permanent current is about 2 000 m.

The replies received indicate that the shunts obtained vary considerably from one Railway system to another and sometimes reach fairly high figures.

In view of the variations reported we will give the minimum values called for under the various circumstances by the S. N. C. F. :

Character of feed current	Length of sections			
	500 m 546 yrds	1 000 m 1 093 yrds	1 500 m 1 640 yrds	2 000 m 2 187 yrds
Direct current	0.5	0.3	0.2	0.15
Alternating current (without impedance bonds)	0.5	—	—	—
Alternating current (with impedance bonds)	0.15	0.15	0.15	0.15
Pulsating direct current	1	0.75	0.5	—
Pulsating alternating current	0.5	0.5	0.5	—

The values are in ohms.

We may add however that certain Railways adopt higher values for some of the above figures.

2. *What are the advantages of coded current track circuits?*

According to the opinion of those Railways having this matter under consideration, the advantages of this system are chiefly as follows :

a) for sections of equal length the shunt is greater than with track circuits of other types;

b) similarly for a given shunt value the length of the sections obtainable with coded track circuits is greater than with any other system;

c) extraneous or leakage currents are less likely to influence the working;

d) it is easier to consider using cab signalling than with any other arrangement.

3. *What economies do you expect to obtain to make good the extra cost of coded current track circuits?*

It would appear from a consideration of all the replies received that practically speaking no economy is obtained by using track circuits. Only the technical advantages set out above are obtained, to compensate in some measure for the greater cost of the code equipment.

4. *What confidence have you in the two systems from the point of view of safety and regularity?*

Opinion is not quite definite on this point. We cannot do better than reproduce the actual wording of the conclusion, with which we are in agreement, reached by the S. N. C. F.

It appears that in every case that from the safety point of view it may be said that coded current signalling is slightly superior to signalling using permanent current in the track circuit, but that, on the other hand, its working appears to be a little less certain in action.

5. *Are the track circuits supplied with current from the Railway supply, through a substation, or from batteries?*

All lines using alternating current track circuits are using power from the « grid » transformed as required in substations.

In the case of direct current track circuits power is also taken from the « grid » and rectified, with it may be a booster battery or a floating battery with trickle-charging. On some lines, here and there, battery track circuits are found.

6. *What is the average distance between the signals?*

The replies received give the following figures :

Denmark : 1 200 to 1 600 m (1 312 yards to 1 749 yards);

Belgium : 800 to 1 210 m (875 yards to 1 323 yards);

France (S. N. C. F.) : 2 000 m (2 187 yards) maximum;

Paris (Transport Board) : 170 m (186 yards) city lines — 350 m (383 yards) Sceaux line;

Norway : 1 000 to 3 000 m (1 094 yards to 3 281 yards);

Netherlands : 1 500 m (1 640 yards);

Switzerland : 750 m (820 yards).

The great differences between the replies given above show that the distance between signals depends above all on two factors :

1) the spacing called for by the traffic department, as a function of the frequency and speed of the trains;

2) the braking distance required.

It is certain that in the case of lines carrying fast trains which have to be equipped with automatic signalling, the signal spacing constitutes one of the essential factors in striking the balance in favour of an increase in speed, having regard to the fact that any alterations made later would prove to be very costly.

There is thus every reason to select a distance between signals which will allow

of high speeds being run. Obviously it is quite another matter on Metropolitan and suburban lines where speed is limited by other circumstances (closeness of the stopping points, presence of tunnels, curves, etc.).

7. *What frequencies are used and what precautions do you take to prevent the coded current of a track circuit affecting that of the adjoining track circuit should the insulated rail joint get broken?*

The frequencies used on the S. N. C. F. lines are 75 and 180 interruptions per minute.

In order to prevent coded current from one track circuit influencing the neighbouring one in the case of breakdown of an insulated joint, it is usual to reverse the polarity of adjacent circuits. In addition polarised code-following relays are used.

8. *What type of insulated rail joint do you use?*

Most of the Railways use insulated joints with either packings of fibre or cotton cloth impregnated with bakelite.

Certain others use laminated joints made of bakelised wood, while on some lines joints with metal plates, with bakelised fibre insulations are being tried.

Some lines are still using wooden joints, or supported joints.

It is certain that in view of the necessity of increasing both speed and comfort the tendency towards using longer and longer rails will grow. The problem of the insulated joint will then become very complicated and most probably new solutions will have to be looked for.

9. *What is the average number of breakdowns of all kinds per signal and per year for your automatic block installations?*

Those lines who keep records on this point, report an average of 0.5 to 0.6 failures per signal per year, which is remarkable in that it is the figure being obtained at the present time with the equipment in question.

The Paris Transport Board gives however an altogether exceptional figure of 0.05 failures per signal per year, of which half is due to the components of the track circuit. Each signal is operated about 120 000 times a year.

It is as well to add here that of the total number of cases on the various lines, the number of danger side failures is practically negligeable.

10. *How does the signalman in charge of a junction on a line fitted with the automatic block know the direction a train approaching one of the two branches of the junction has to take?*

On most lines where this case is met with the signalman is advised of the class of train approaching by telephone, either from the station in the rear or by the dispatcher or traffic controller.

On the lines operated by the Paris Transport Board all trains carry a number in front and in rear clearly distinguishable as an identification number. In addition the signalmen are given a working graphic timetable, and are advised by telephone when the case requires it of any change being made in the running of the trains. In this way, as soon as one train passes they can set up the route for the next.

11. *When the automatic block is used, drivers are allowed to run past certain signals at danger but not others. How is the driver to be made to know when he is allowed to run past a signal at danger?*

On certain Railways, such as the Danish, Norwegian and Swiss, a train may only pass an automatic signal at danger after receipt of a telephone authorisation from the nearest signal box or station. On the Belgian and French lines two distinct types of stop signal are used:

a) an absolute stop signal, which may only be passed on authority received from the nearest station or signal box;

b) a permissive (automatic) stop signal which the driver is authorised to pass on his own account proceeding to the next signal prepared to stop short within range of vision.

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